Marketing Systems Group

Composite Weighting For Hybrid Samples

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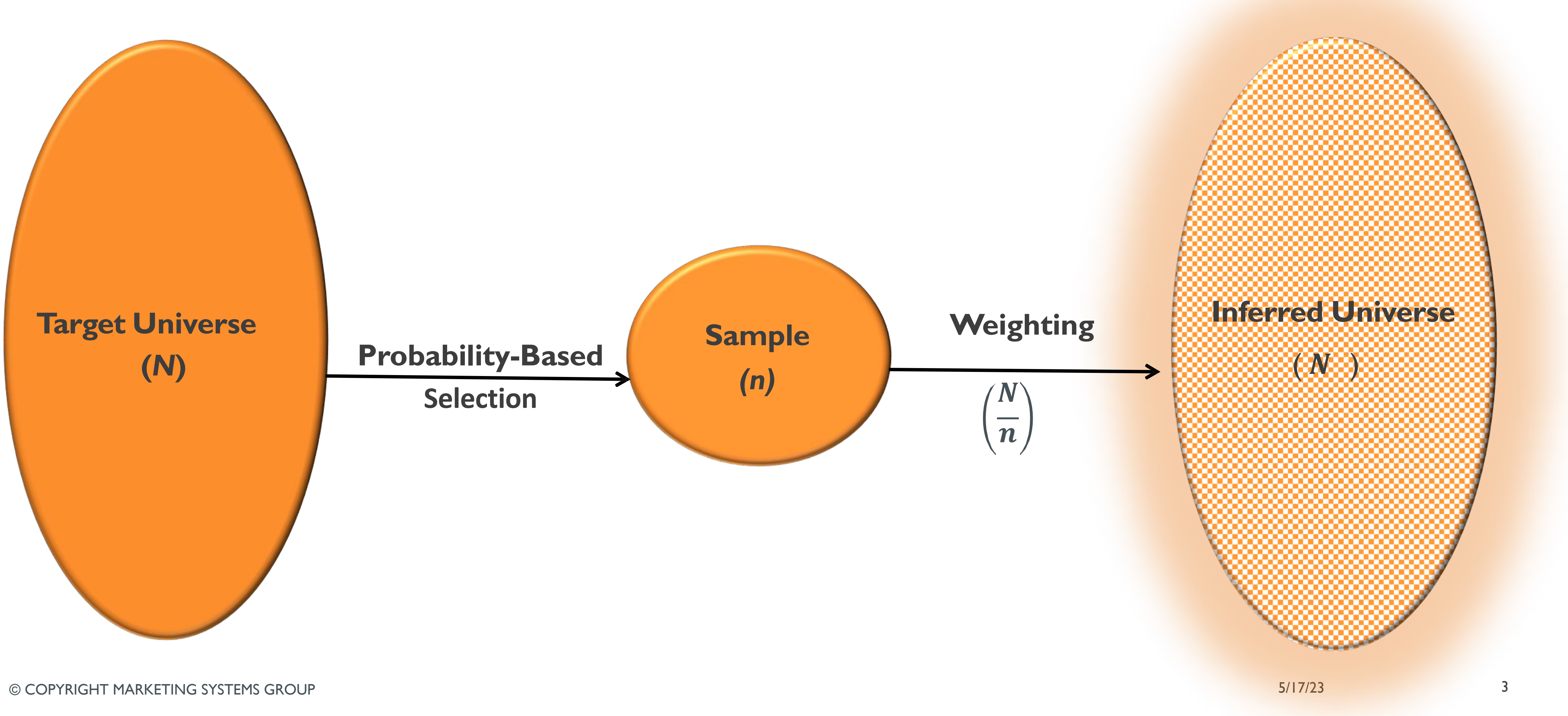
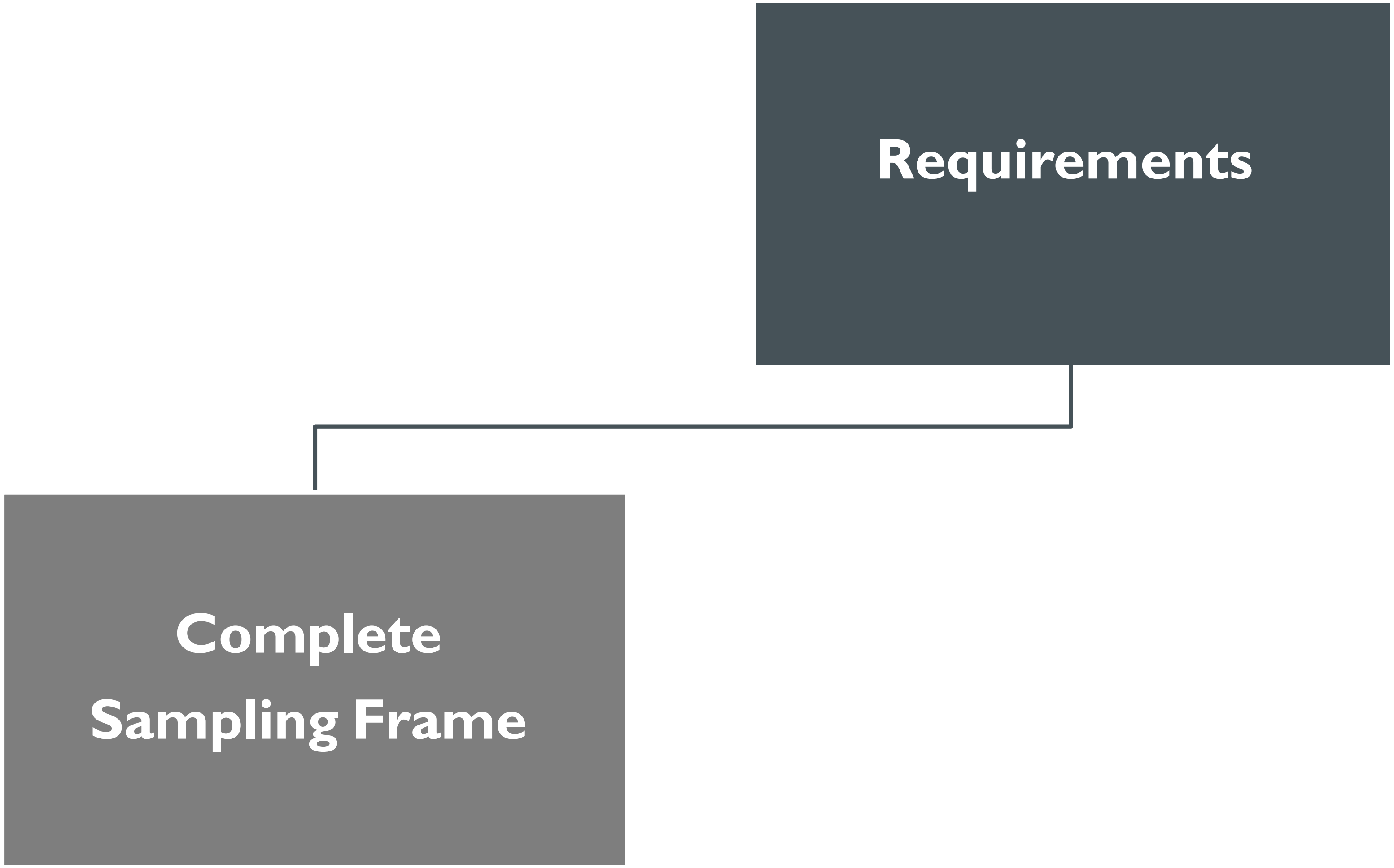
PRESENTATION OUTLINE

- **Traditional Inferential Paradigm**
- **New Realities in the Digital Age**
- **Integration of Surveys**
  - **Improvisations**
  - **Composite Estimation**
  - **Composite Weighting**
- **Takeaways**

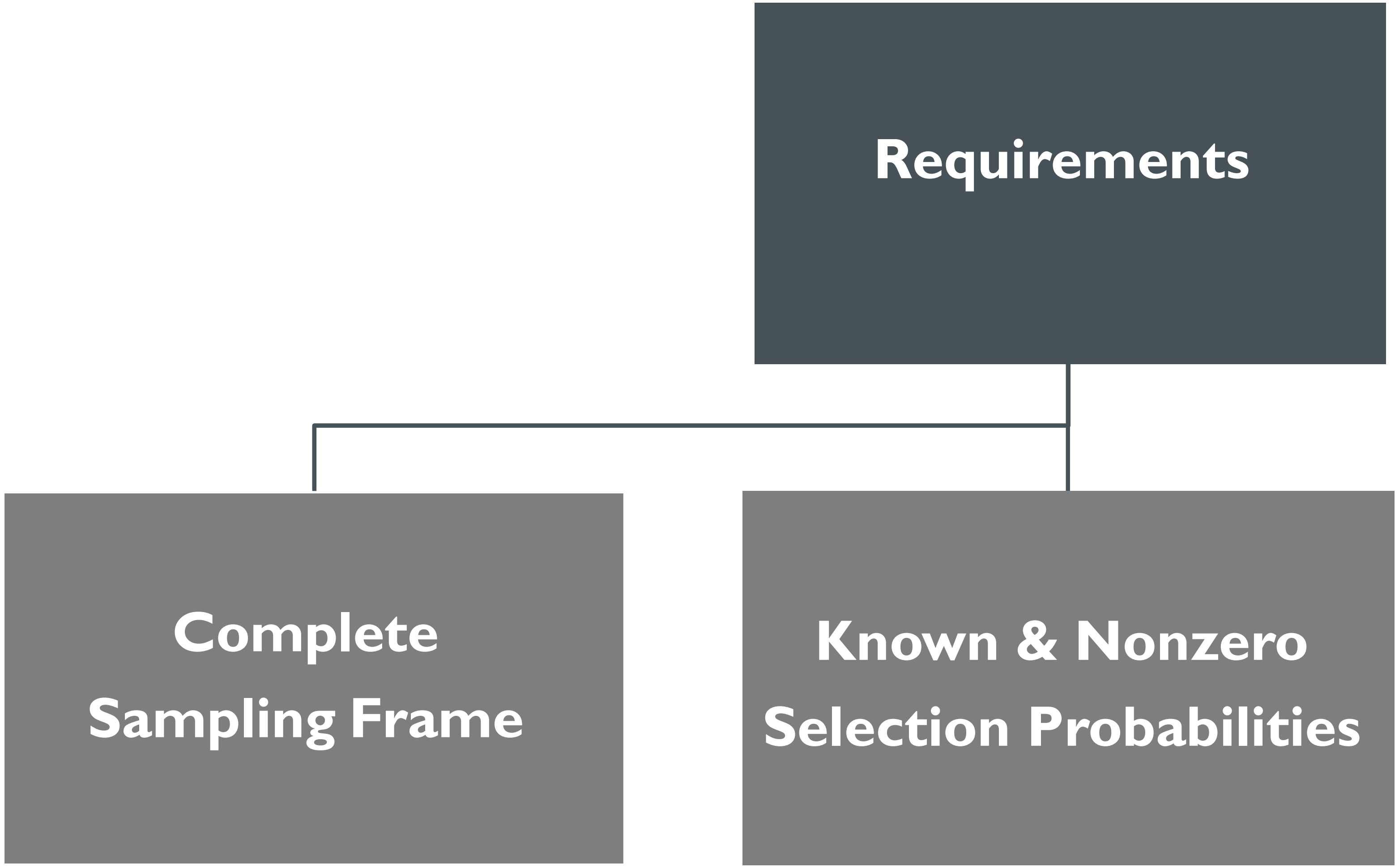
TRADITIONAL INFERENTIAL PARADIGM



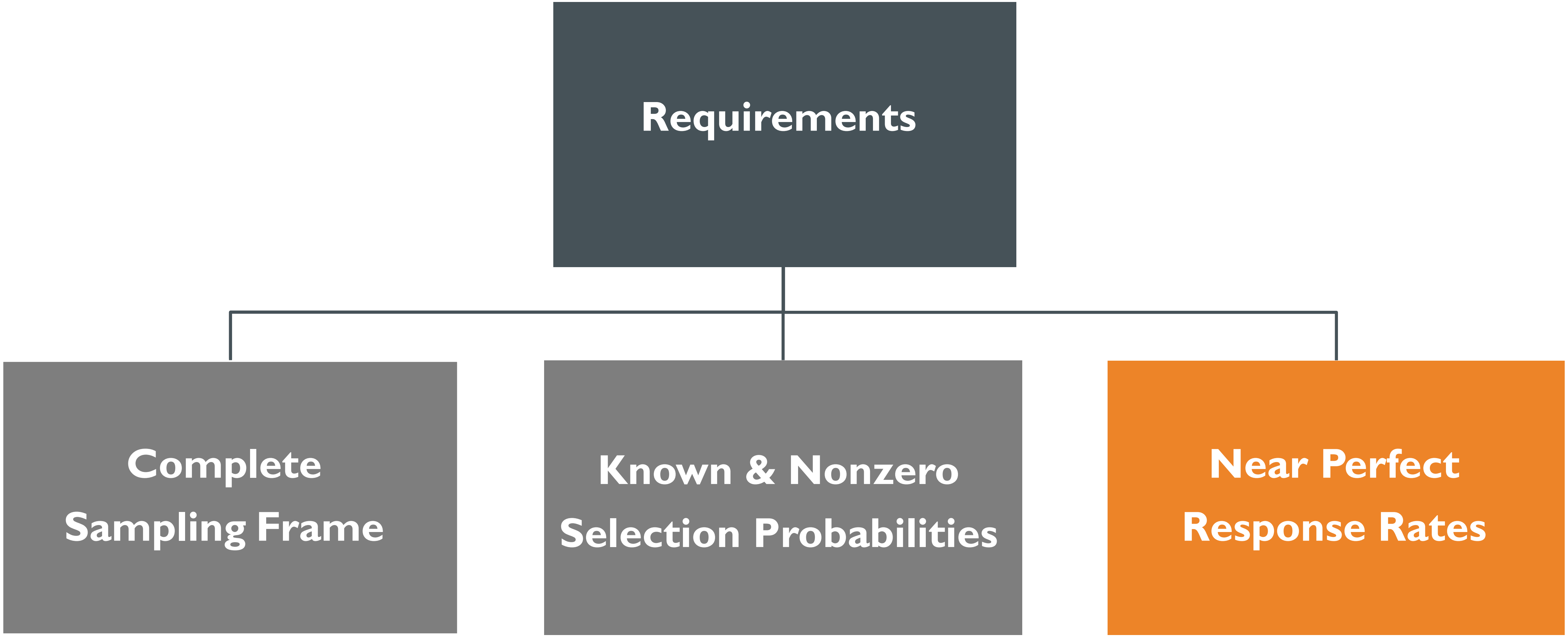
TRADITIONAL INFERENTIAL PARADIGM



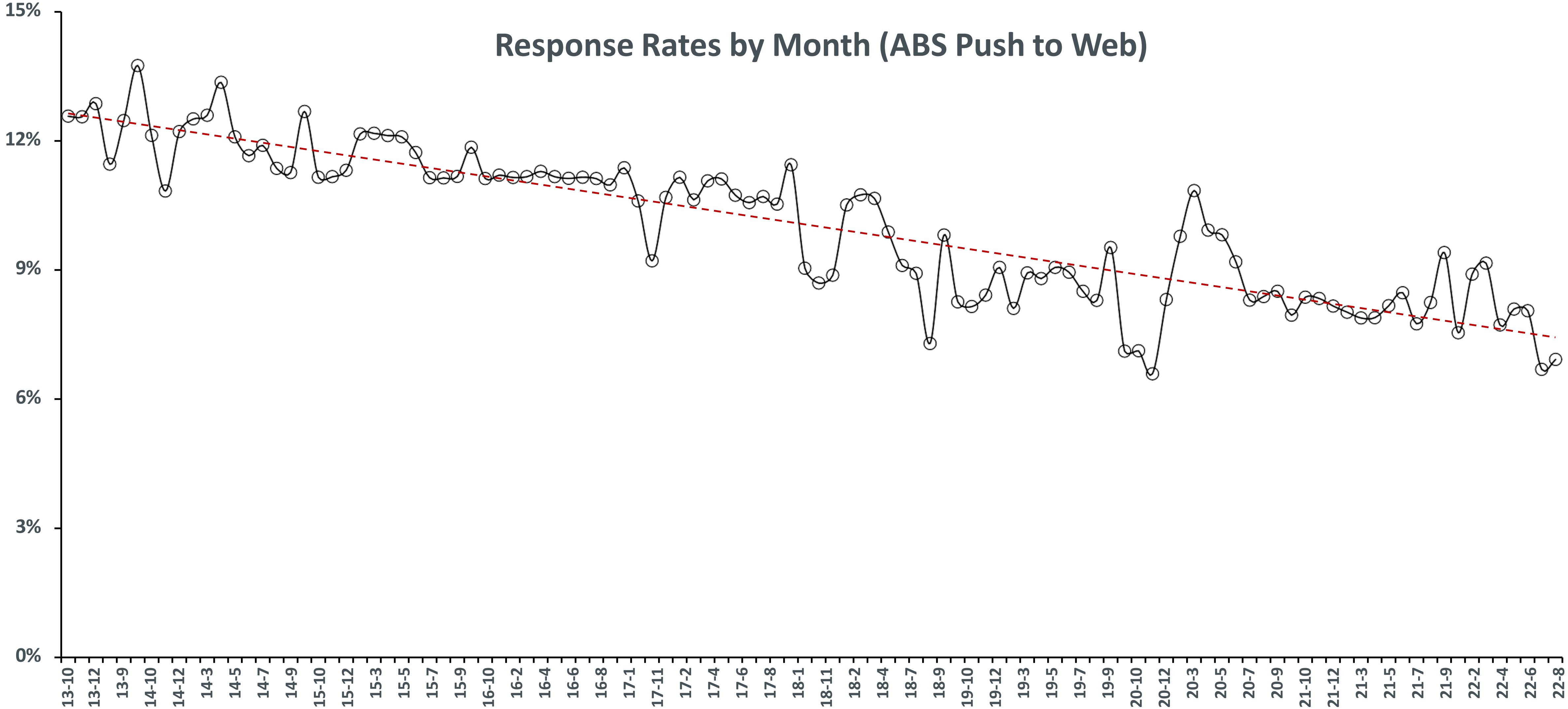
TRADITIONAL INFERENTIAL PARADIGM



TRADITIONAL INFERENTIAL PARADIGM



NEW REALITIES IN THE DIGITAL AGE



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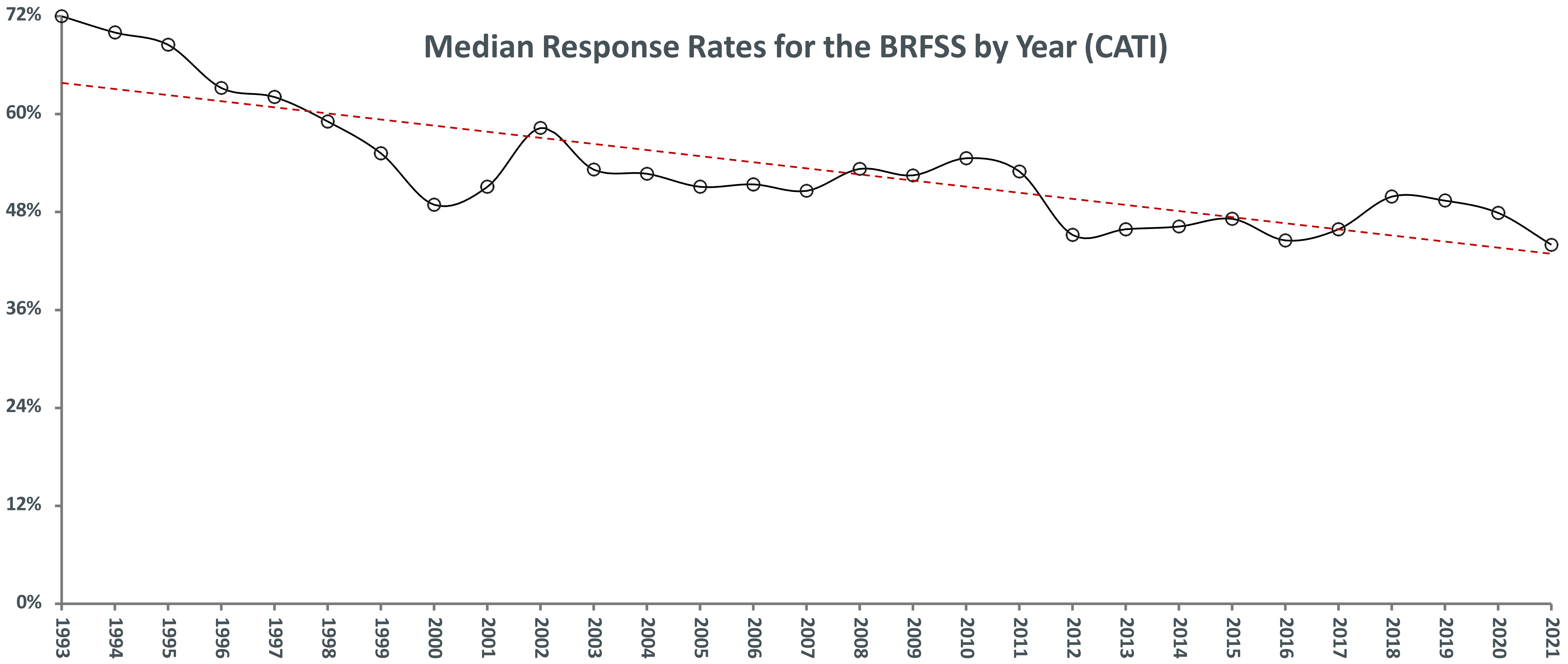
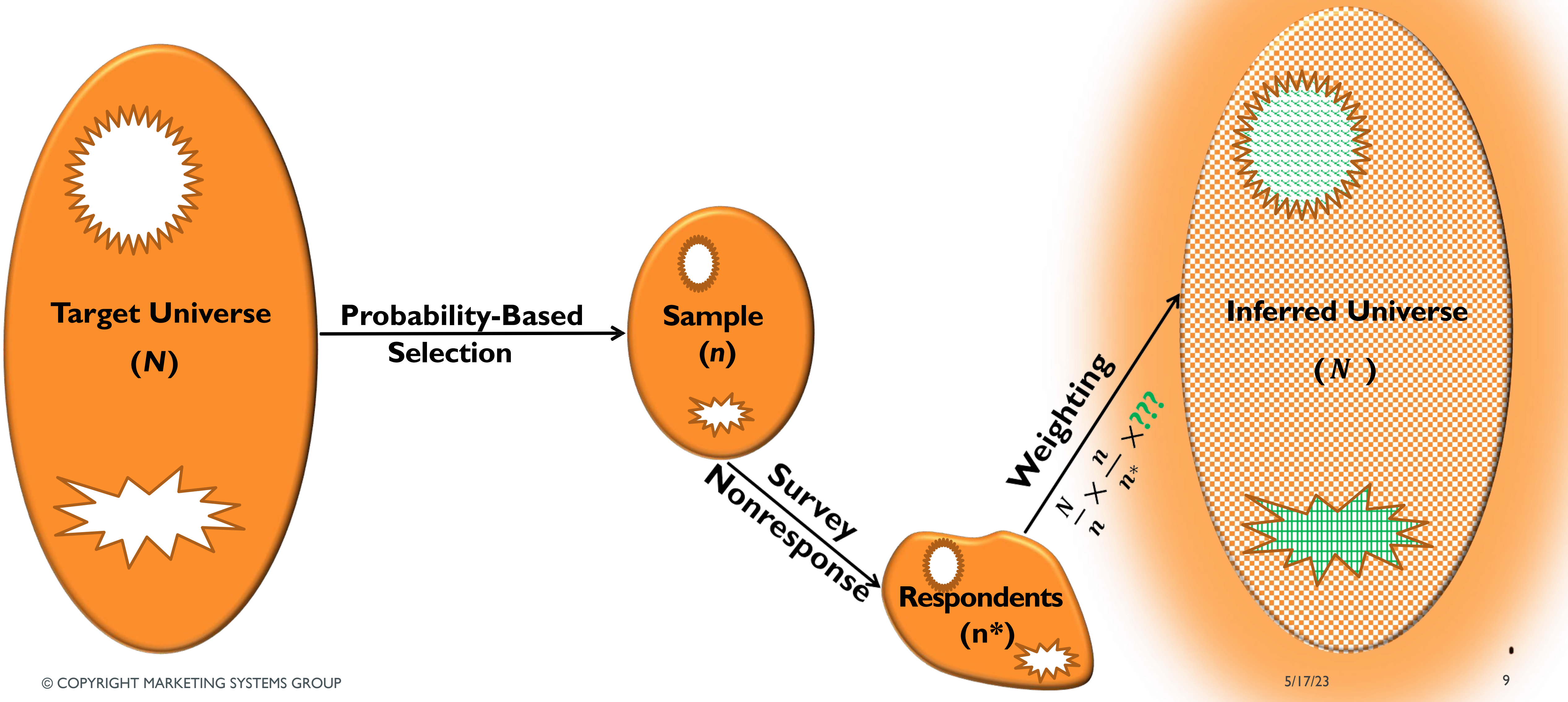


NEW REALITIES IN THE DIGITAL AGE



NEW REALITIES IN THE DIGITAL AGE

- **Multi-Mode:**
  - Was considered hasty but now encouraged to improve coverage
  - Different modes appeal to different cohorts
- **Multi-Frame Samples:**
  - Was considered worthy of commercial surveys but now is growing in popularity
  - Can improve coverage and reduce survey cost
- **Hybrid Samples:**
  - Probability samples: RDD + ABS
  - Semi-probability samples: RDD or ABS + nonprobability
  - Nonprobability samples: nonprobability + nonprobability

INTEGRATION OF SURVEYS

- **Improvisations:**
  - Stack unweighted surveys
  - Stack weighted surveys
- **Composite Estimation:**
  - Weight individual surveys separately
  - Produce point estimates from separate surveys
  - Blend individual estimates together
- **Composite Estimation Issues:**
  - Resource intensive
  - Inferentially inefficient
  - Not conducive to small domain estimations
- **Composite Weighting:**
  - Combining different survey components together
  - Weighting the combined data as a single survey

COMPOSITE ESTIMATION

Two Independent Sample Surveys:

- Sample sizes: n_1 and n_2
- Estimating population mean $\bar{Y}$ via $\bar{y}_1$ and $\bar{y}_2$

Composite Estimator: $\bar{y} = \alpha\bar{y}_1 + (1-\alpha)\bar{y}_2$

If α = 0.5 Then: $\bar{y} = \frac{\bar{y}_1+\bar{y}_2}{2}$

Optimal α Requires Minimizing: $MSE(\bar{y}) = V(\bar{y}) + [B(\bar{y})]^2$

If $B(\bar{y}_1) > 0, B(\bar{y}_2) > 0, V(\bar{y}_1) \neq V(\bar{y}_2)$ **Then:**

$$\alpha_{optimal} = \frac{MSE(\bar{y}_2)}{MSE(\bar{y}_1)+MSE(\bar{y}_2)} = \frac{V(\bar{y}_2)+[B(\bar{\boldsymbol{y}}_2)]^2}{V(\bar{y}_1)+[B(\bar{\boldsymbol{y}}_1)]^2+V(\bar{y}_2)+[B(\bar{\boldsymbol{y}}_2)]^2}$$

COMPOSITE ESTIMATION

If $B(\bar{y}_1) = 0$ **but** $B(\bar{y}_2) \neq 0, V(\bar{y}_1) \neq V(\bar{y}_2)$ **Then:**

$$\alpha_{optimal} = \frac{MSE(\bar{y}_2)}{V(\bar{y}_1)+MSE(\bar{y}_2)} = \frac{V(\bar{y}_2)+[B(\bar{y}_2)]^2}{V(\bar{y}_1)+V(\bar{y}_2)+[B(\bar{y}_2)]^2}$$

If $B(\bar{y}_1) = 0$ **and** $B(\bar{y}_2) = 0, V(\bar{y}_1) \neq V(\bar{y}_2)$ **Then:**

$$\alpha_{optimal} = \frac{V(\bar{y}_2)}{V(\bar{y}_1) + V(\bar{y}_2)}$$

If $B(\bar{y}_1) = B(\bar{y}_2) = 0$ **and** $V(\bar{y}_1) \approx V(\bar{y}_2)$ **Then:**

$$\alpha_{optimal} = \frac{n_1}{n_1 + n_2} = \frac{n_1}{n}$$

COMPOSITE ESTIMATION

Age	Smoking Behavior	Survey Estimate			
		Survey 1 (n = 3,361)		Survey 2 (n = 3,788)	
		Prevalence		Prevalence	
Overall	Cigarette	5.6%		16.9%	
	E-cigarette	13.5%		20.8%	
15- 17	Cigarette	2.3%		5.5%	
	E-cigarette	9.1%		10.4%	
18 - 24	Cigarette	7.0%		22.1%	
	E-cigarette	15.5%		25.5%	

COMPOSITE ESTIMATION

Age	Smoking Behavior	Survey Estimate				$\alpha = \frac{1}{2}$	
		Survey 1 (n = 3,361)		Survey 2 (n = 3,788)		Factor	Estimate
		Prevalence		Prevalence			
Overall	Cigarette	5.6%		16.9%		0.5	11.24%
	E-cigarette	13.5%		20.8%			17.15%
15- 17	Cigarette	2.3%		5.5%			3.94%
	E-cigarette	9.1%		10.4%			9.76%
18 - 24	Cigarette	7.0%		22.1%			14.54%
	E-cigarette	15.5%		25.5%			20.50%

COMPOSITE ESTIMATION

Age	Smoking Behavior	Survey Estimate				$\alpha = \frac{1}{2}$		$\alpha_{optimal} = \frac{V_2}{(V_1+V_2)}$	
		Survey 1 (n = 3,361)		Survey 2 (n = 3,788)		Factor	Estimate	Factor	Estimate
		Prevalence	Variance	Prevalence	Variance				
Overall	Cigarette	5.6%	0.00004	16.9%	0.00007	0.5	11.24%	0.64	9.7%
	E-cigarette	13.5%	0.00008	20.8%	0.00009		17.15%	0.52	17.0%
15- 17	Cigarette	2.3%	0.00004	5.5%	0.00009		3.94%	0.70	3.3%
	E-cigarette	9.1%	0.00017	10.4%	0.00017		9.76%	0.49	9.8%
18 - 24	Cigarette	7.0%	0.00007	22.1%	0.00012		14.54%	0.62	12.7%
	E-cigarette	15.5%	0.00013	25.5%	0.00015		20.50%	0.52	20.3%

COMPOSITE WEIGHTING

Individually Poststratified Weights:

$$\begin{cases} W_{1i} = B_{1i} \times \frac{N}{\sum_{i=1}^{n_1} B_{1i}}, i = 1, \dots, n_1 \\ W_{2j} = B_{2j} \times \frac{N}{\sum_{j=1}^{n_2} B_{2j}}, j = 1, \dots, n_2 \end{cases}$$

If $B(\bar{y}_1) = B(\bar{y}_2) = 0$ **and** $V(\bar{y}_1) \approx V(\bar{y}_2)$ **Then:**

$$\begin{cases} W_{1i}^* = W_{1i} \times \frac{n_1}{n} = B_{1i} \times \frac{N}{\sum_{i=1}^{n_1} B_{1i}} \times \frac{n_1}{n}, i = 1, \dots, n_1 \\ W_{2j}^* = W_{2j} \times \frac{n_2}{n} = B_{2j} \times \frac{N}{\sum_{j=1}^{n_2} B_{2j}} \times \frac{n_2}{n}, j = 1, \dots, n_2 \end{cases}$$

Use the Above as Base weights and Poststratify the Combined Sample

COMPOSITE WEIGHTING

If $B(\bar{y}_1) = 0,\ B(\bar{y}_2) = 0$**, and** $V(\bar{y}_1) \neq V(\bar{y}_2)$ **Then:**

$$\begin{cases} W_{1i}^{*} = W_{1i} \times \frac{n_1^*}{n^*} = B_{1i} \times \frac{N}{\sum_{i=1}^{n_1} B_{1i}} \times \frac{n_1^*}{n^*}, i = 1, \dots, n_1 \\ W_{2j}^{*} = W_{2j} \times \frac{n_2^*}{n^*} = B_{2j} \times \frac{N}{\sum_{j=1}^{n_2} B_{2j}} \times \frac{n_2^*}{n^*}, j = 1, \dots, n_2 \end{cases}$$

Where:

$$n_i^* = \frac{n_i}{\delta_i}$$

$$\delta_i = 1 + \frac{\sum_{k=1}^{n_i} \frac{(W_{ik} - \bar{W}_i)^2}{n_i - 1}}{\bar{W}_i^2}$$

COMPOSITE WEIGHTING

Combined Poststratification:

- Accept the calibrated pooled survey weights as base weights
- Apply some power transformation to reduce the variability of the base weights
- Poststratify the combined sample using the resulting base weights

Inferential Benefits:

- Can use more granular weighting adjustments
- All respondents will be weighted to a consistent set of benchmarks
- A consistent method will be used for variance estimations

Computational Benefits:

- A single set of weights to work with
- No piecemeal process to create dozens of composition factors and estimates
- Reduce "contamination" from smaller surveys

COMPOSITE WEIGHTING – NUMERICAL EXAMPLE

Age	Smoking Behavior	Survey Estimates		Composite Estimates		Composite Weighting
		Survey 1	Survey 2	$\alpha = \frac{1}{2}$	$\alpha = \frac{V_2}{(V_1+V_2)}$	
Overall	Cigarette	5.6%	16.9%	11.2%	9.7%	10.5%
	E-cigarette	13.5%	20.8%	17.2%	17.0%	16.3%
15- 17	Cigarette	2.3%	5.5%	3.9%	3.3%	3.6%
	E-cigarette	9.1%	10.4%	9.8%	9.8%	9.1%
18 - 24	Cigarette	7.0%	22.1%	14.5%	12.7%	13.6%
	E-cigarette	15.5%	25.5%	20.5%	20.3%	19.5%

TAKEAWAYS

New Realities of the Accelerating Digital Age:

- Traditional sampling methods have growing issues: coverage, time, and cost
- Perfect coverage and high response rates are dwindling luxuries
- Unwavering allegiance to traditional methods just for the sake of optics is getting old
- Alternative (hybrid) sampling methods are becoming more pragmatic

Making Reliable Inferences from Imperfect Data:

- All reasonable attempts must be made to improve representation
- Surveys need more comprehensive weighting due to low coverage and response rates
- Compensation methods for hybrid samples must be approachable and scalable
- Composite weighting offer a simple and effective approach for blending hybrid samples

THANK YOU

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