BUDGET UNCERTAINTY IN A COORDINATED VACCINE MARKET

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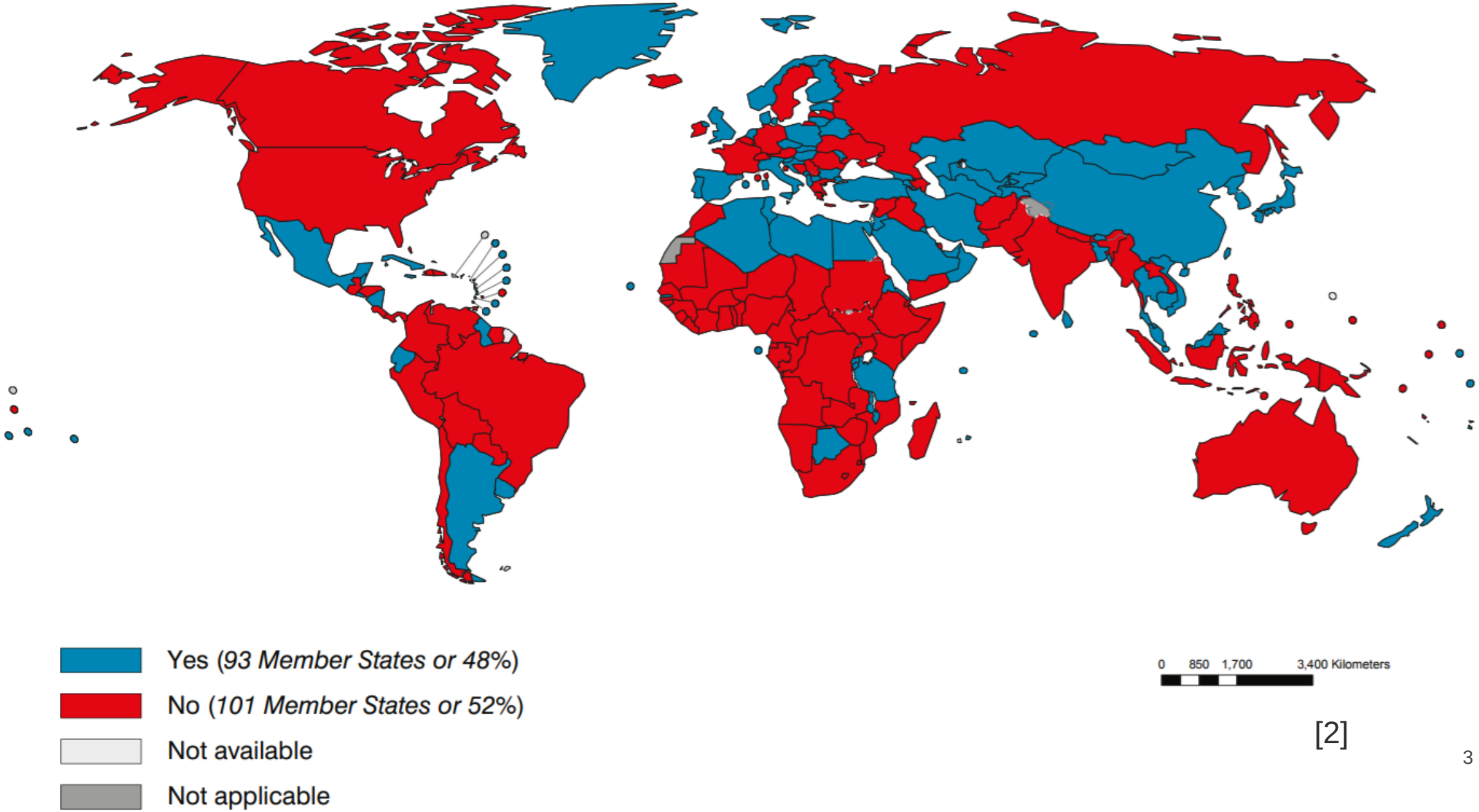
Funded by the Bill and Melinda Gates Foundation – Grant Number: OP1152241

Agenda

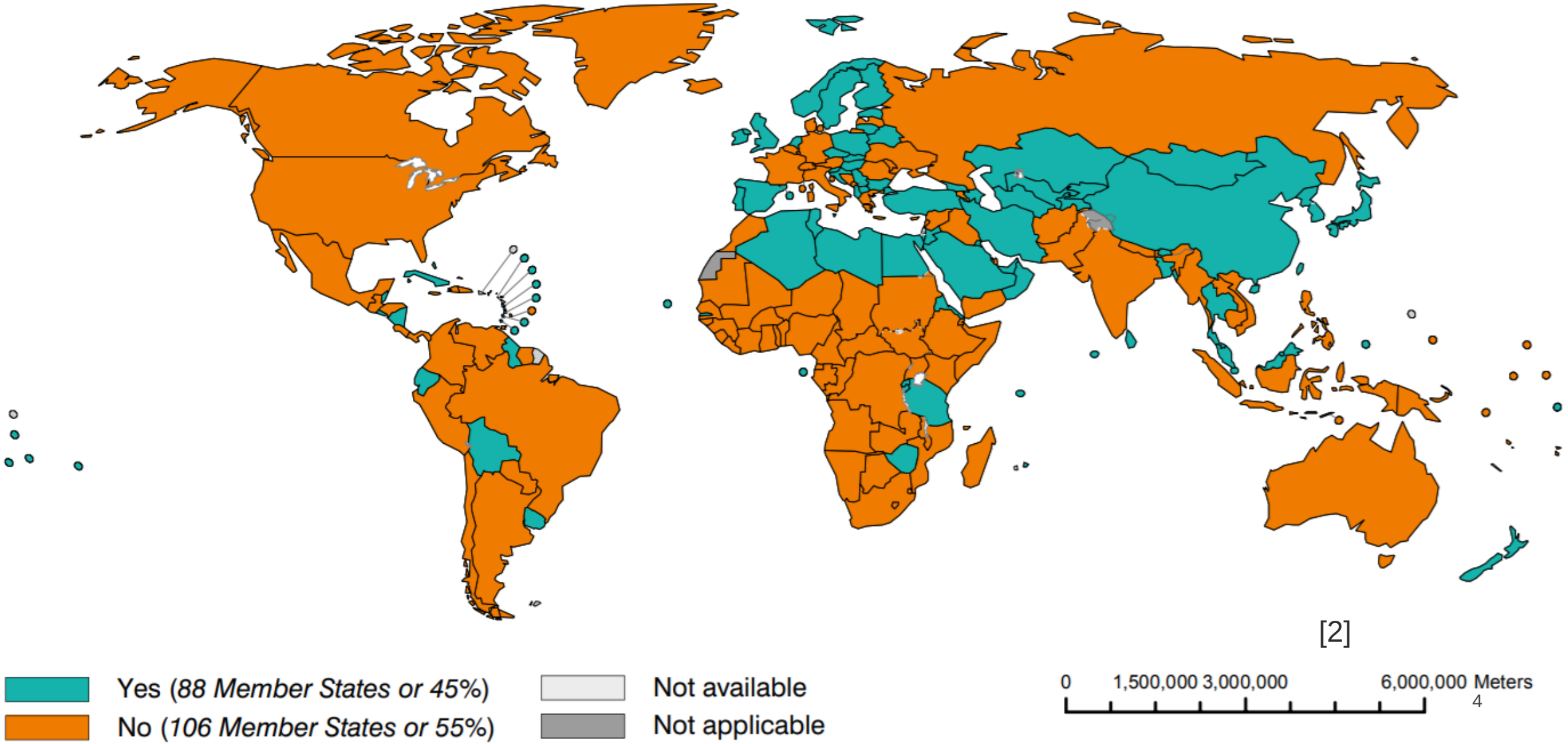
- Problem Introduction
- Research Questions
- Hypotheses
- Methods
- Results
- Conclusions

Figure 3: Member States that have and have not achieved national coverage of ≥ 90% for all vaccines included in the national infant immunization schedule in 2012



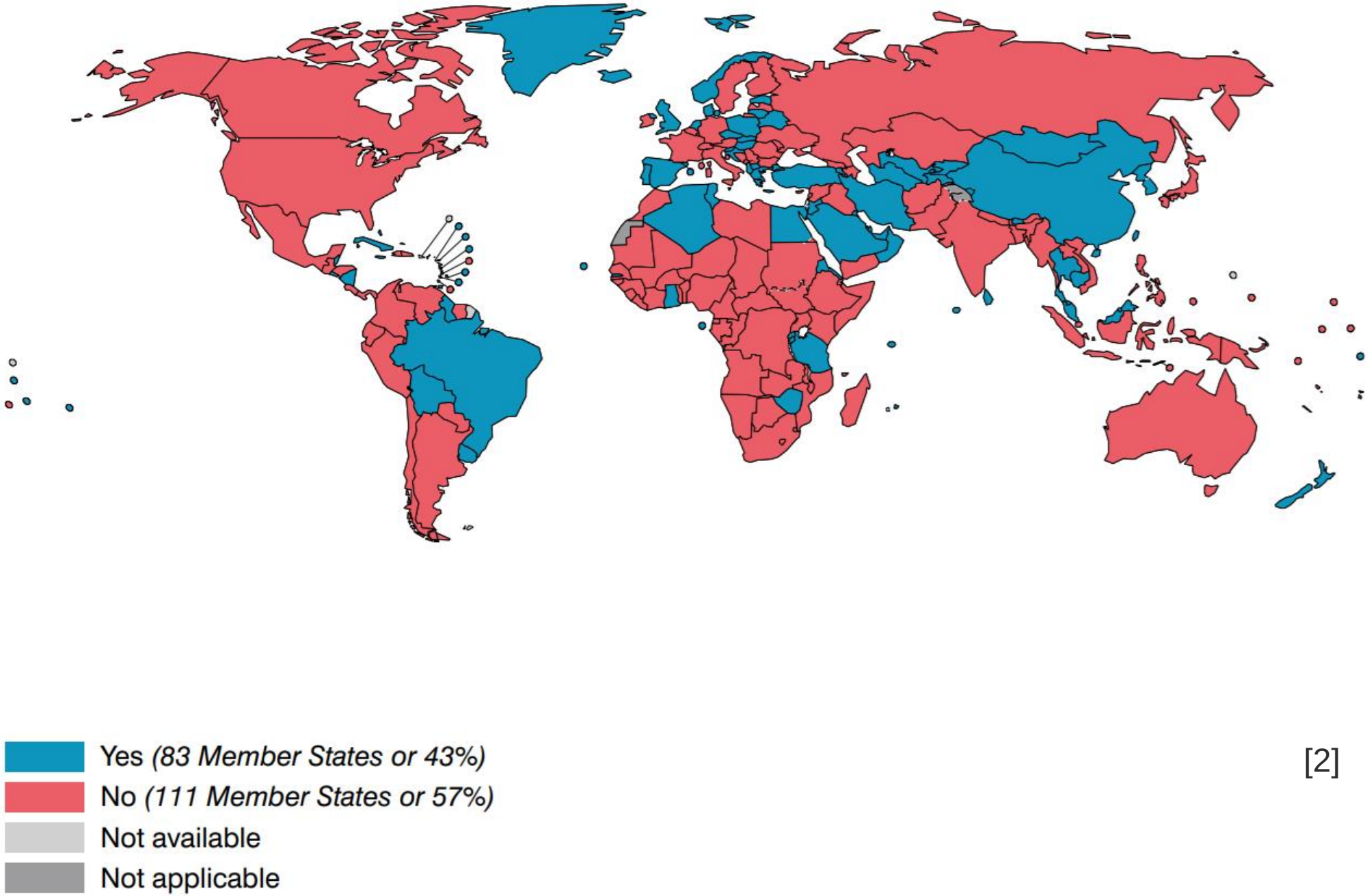
[2]

Figure 19: Member States that have achieved national coverage of ≥90% for all vaccines included in the national infant immunization schedule, 2013



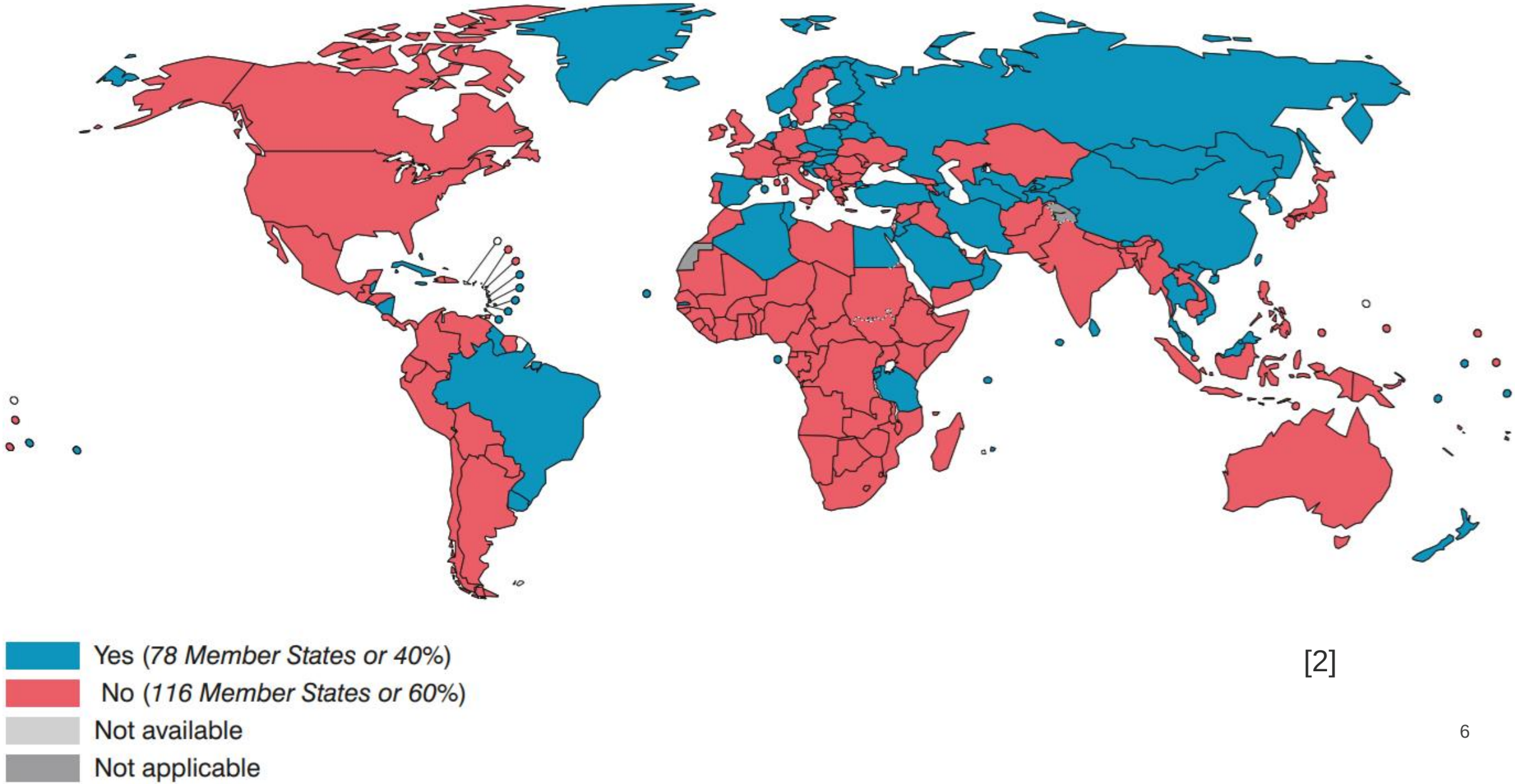
[2]

Figure 21: Member States that achieved national coverage of ≥ 90% for all vaccines included in their national infant immunization schedule in 2014



[2]

Figure 2.9: Member States that achieved national coverage of ≥ 90% for all vaccines included in the national infant immunization schedule, 2015[a]

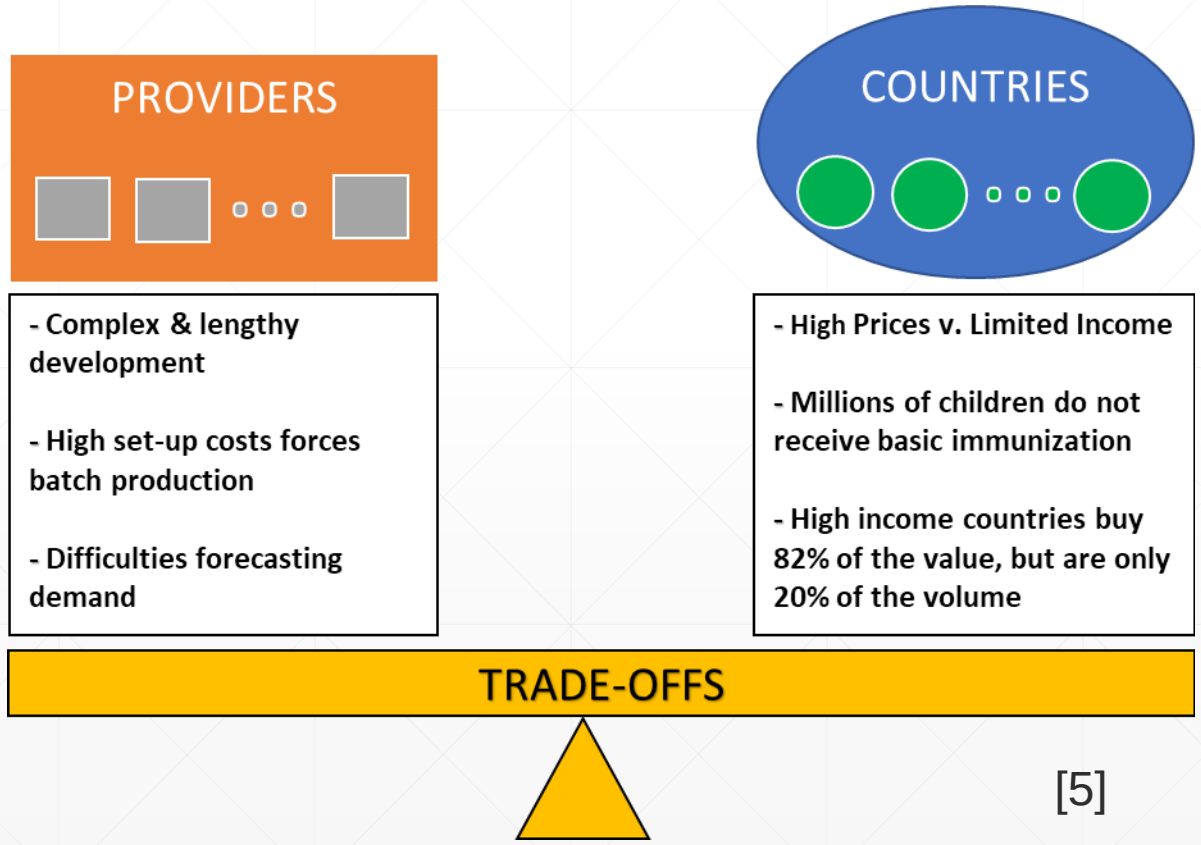


[2]

Problem Introduction

Vaccine Affordability

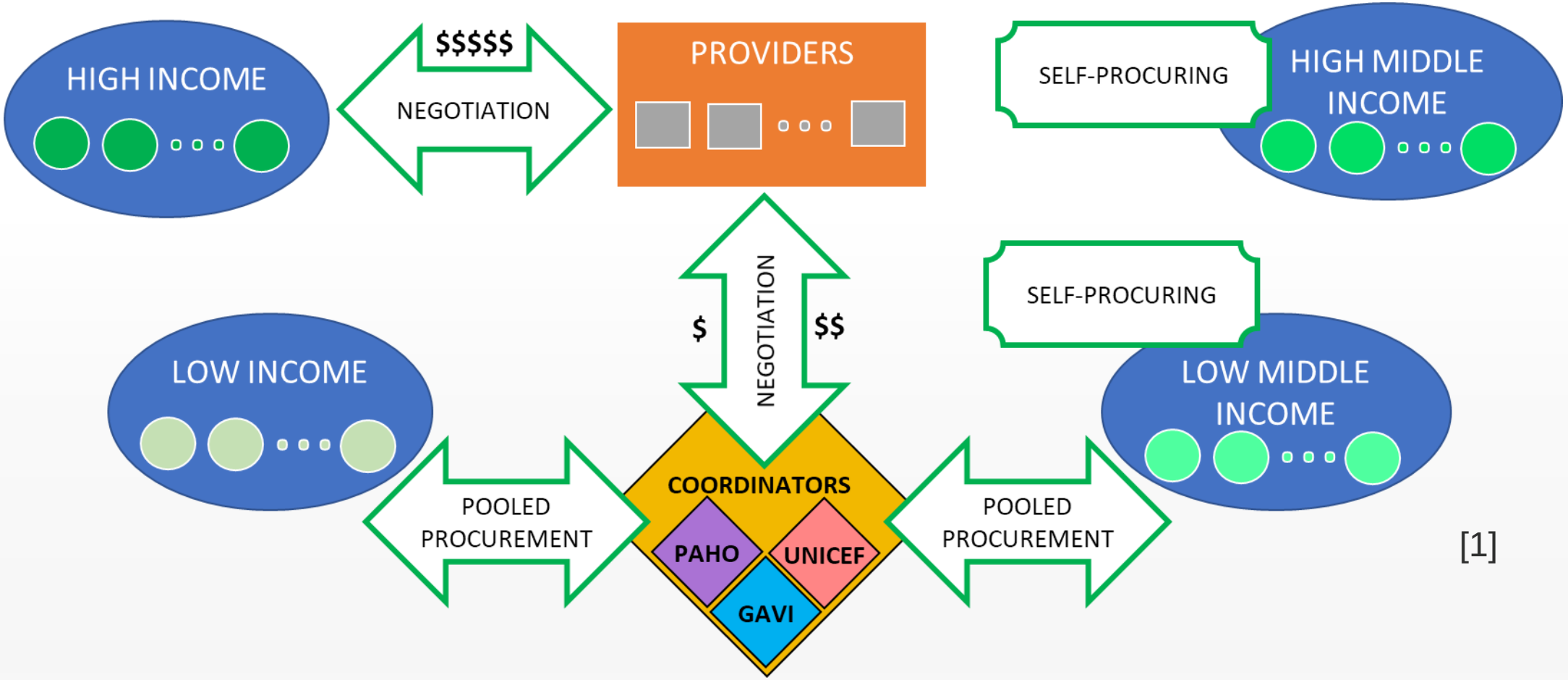
- “Inadequate financing and difficult access to supply are currently seen as a bottleneck for countries achieving and sustaining national, regional and global immunization goals” [2]



[5]

Problem Introduction

Current Vaccine Market

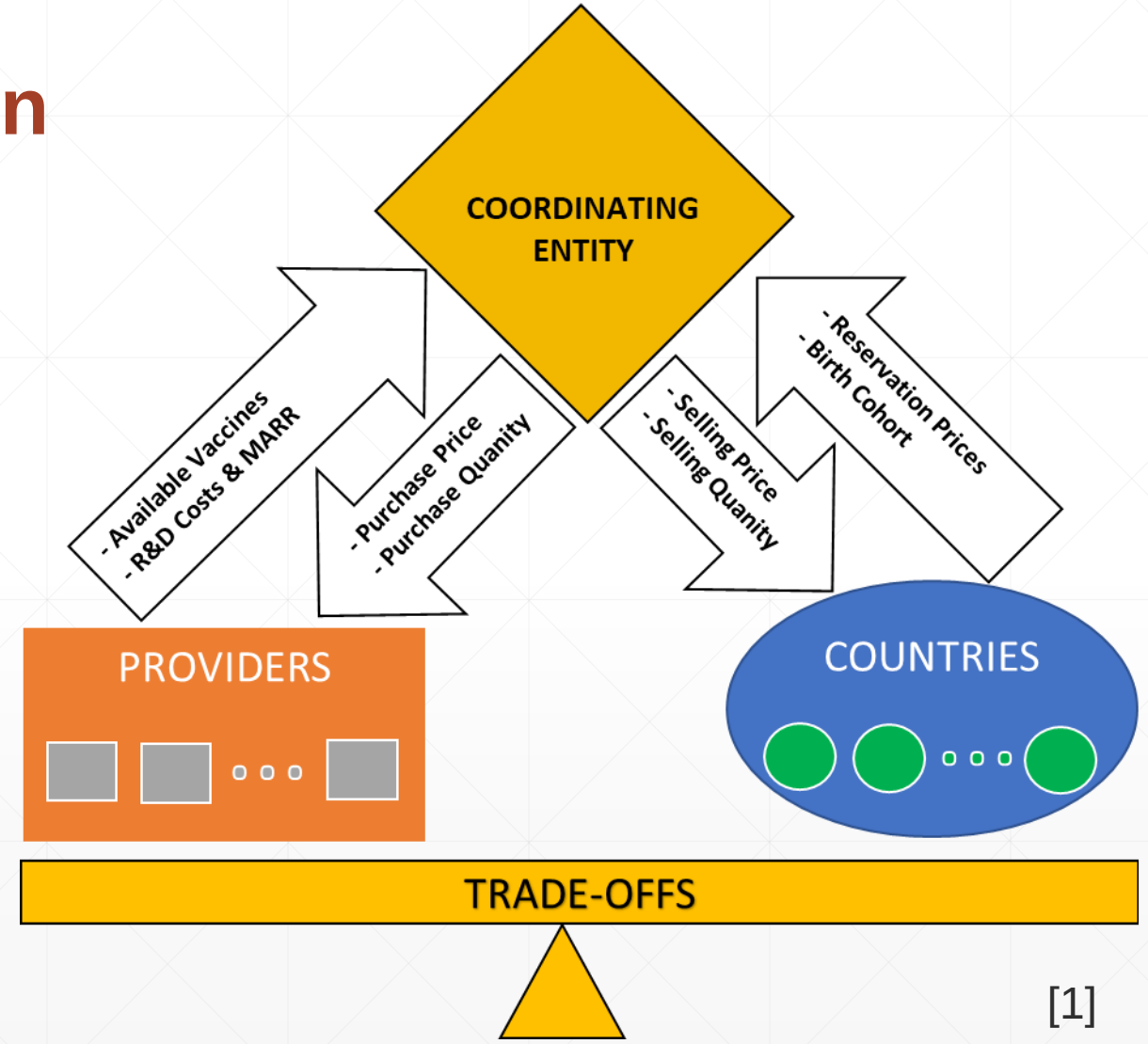


[1]

Problem Introduction

Fully Coordinated Vaccine Market

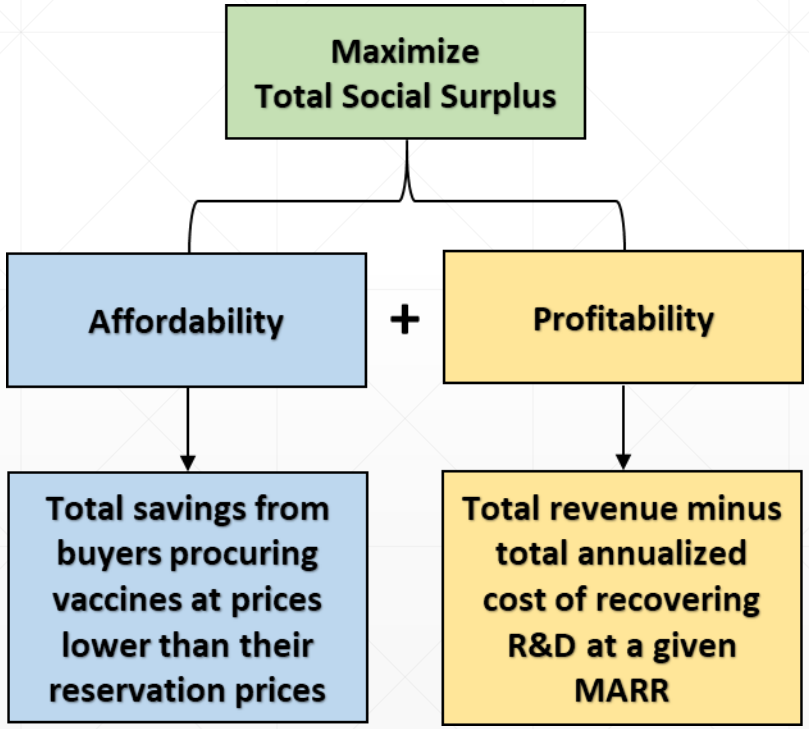
- “Pooled procurement mechanisms manage to secure lower prices than self-procuring countries, except for self-procuring countries purchasing very large volumes” [2]



[1]

Problem Introduction

Antigen Bundling Problem – Objective



[1]

Problem Introduction

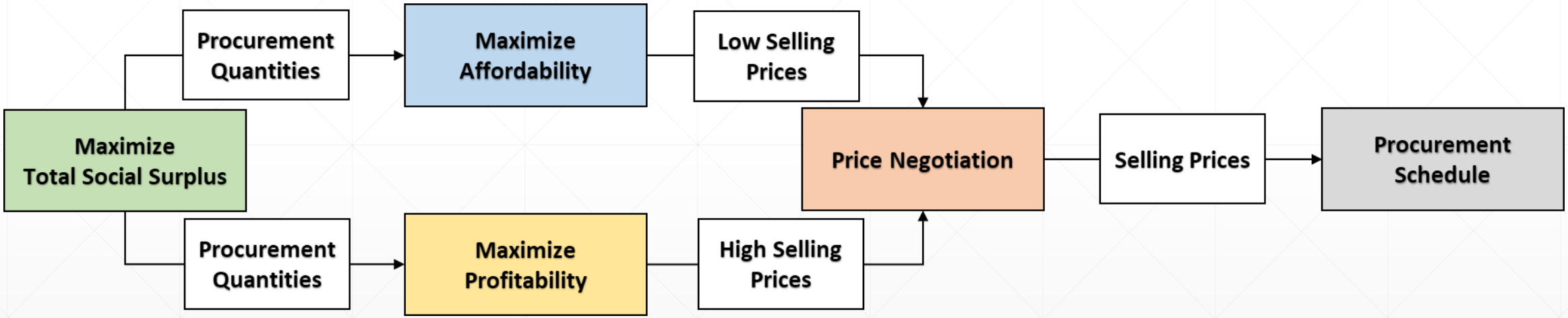
Antigen Bundling Problem – Constraints

Demand	Antigen demand must be satisfied at each market segment
Affordable Pricing	Vaccines must be priced below their reservation price in each market segment
Tiered Based Pricing	Vaccines are priced higher for market segments with higher GNI per capita
Demand Elasticity	Vaccine demand resistantly decreases as its price reaches its reservation price
Combination Vaccine Value	The savings from a combination vaccine must be higher than the savings from any group of vaccines that could satisfy the same demand
Profitable Pricing	Revenue from vaccine sales must ensure a given ROI to vaccine providers
Supply	Providers cannot supply vaccines exceeding their manufacturing capacities

[1]

Problem Introduction

Antigen Bundling Problem – An Optimization Process



[1]

Problem Introduction

Antigen Bundling Problem – Key Findings

- Total social surplus only depends on the choice and quantity of vaccines to buy and not on their price
- Increasing market segmentations improve affordability and profitability in the face of reservation price uncertainty

[1]

Problem Introduction

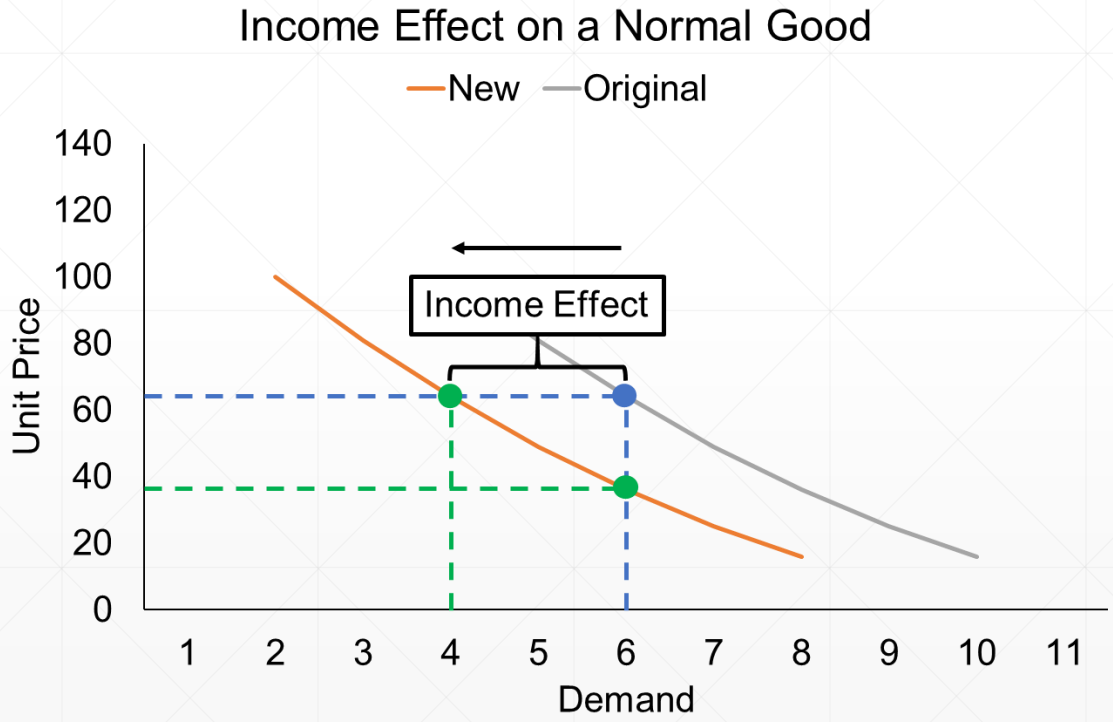
Vaccine Pricing

Paper Name	Authors	Year	Scope	Approach
Pediatric vaccine procurement policy: The monopsonist's problem	Matthew J. Robbins, Sheldon H. Jacobson	2011	USA	Deterministic Optimization
Making combination vaccines more accessible to low-income countries: The antigen bundle pricing problem	Ruben A. Proano, Sheldon H. Jacobson, Wenbo Zhang	2011	Global	Deterministic Optimization
The Weighted Set Covering Game: A Vaccine Pricing Model for Pediatric Immunization	Matthew J. Robbins, Sheldon H. Jacobson, Uday V. Shanbhag,	2014	USA	Game Theory
A bilevel formulation of the pediatric vaccine pricing problem	Matthew J. Robbins, Brian J. Lunday	2015	USA	Game Theory
Asymmetric Bertrand-Edgeworth-Chamberlin Competition with Linear Demand: A Pediatric Vaccine Pricing Model	Matthew J. Robbins, Sheldon H. Jacobson, Banafsheh Behzad	2015	USA	Game Theory
A symmetric capacity-constrained differentiated oligopoly model for the United States pediatric vaccine market with linear demand	Matthew J. Robbins, Brian J. Lunday	2016	USA	Game Theory
Informing pediatric vaccine procurement policy via the pediatric formulary design, pricing, and production problem	Sheldon H. Jacobson, Banafsheh Behzad	2016	USA	Deterministic Optimization

Problem Introduction

Positive Income Elasticity

- The income elasticity for vaccine expenditure is 0.336 for 84 countries from 2010 to 2011 [3]



[4]

Research Questions

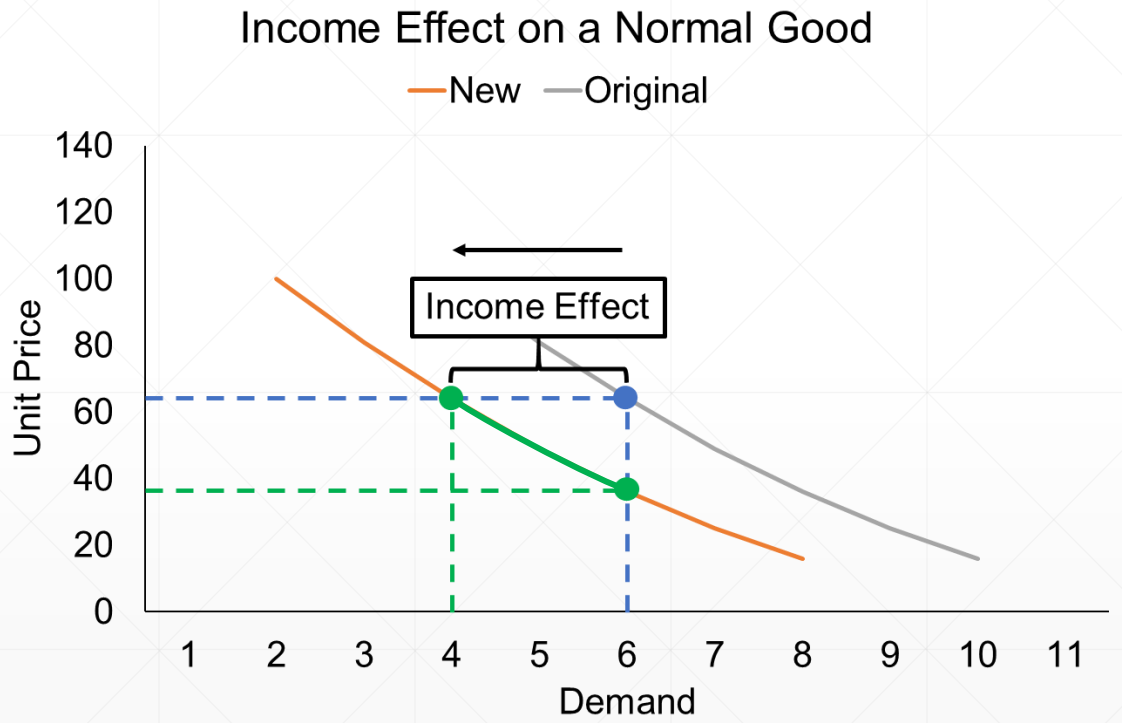
Budget Uncertainty

- When countries face a reduction in budget, how is the welfare of consumers and providers affected?
- How can the behavior of budget reduction be modeled?

Hypothesis

Reservation Price

- If a market's vaccine budget decreases then their reservation price decreases.



Methods

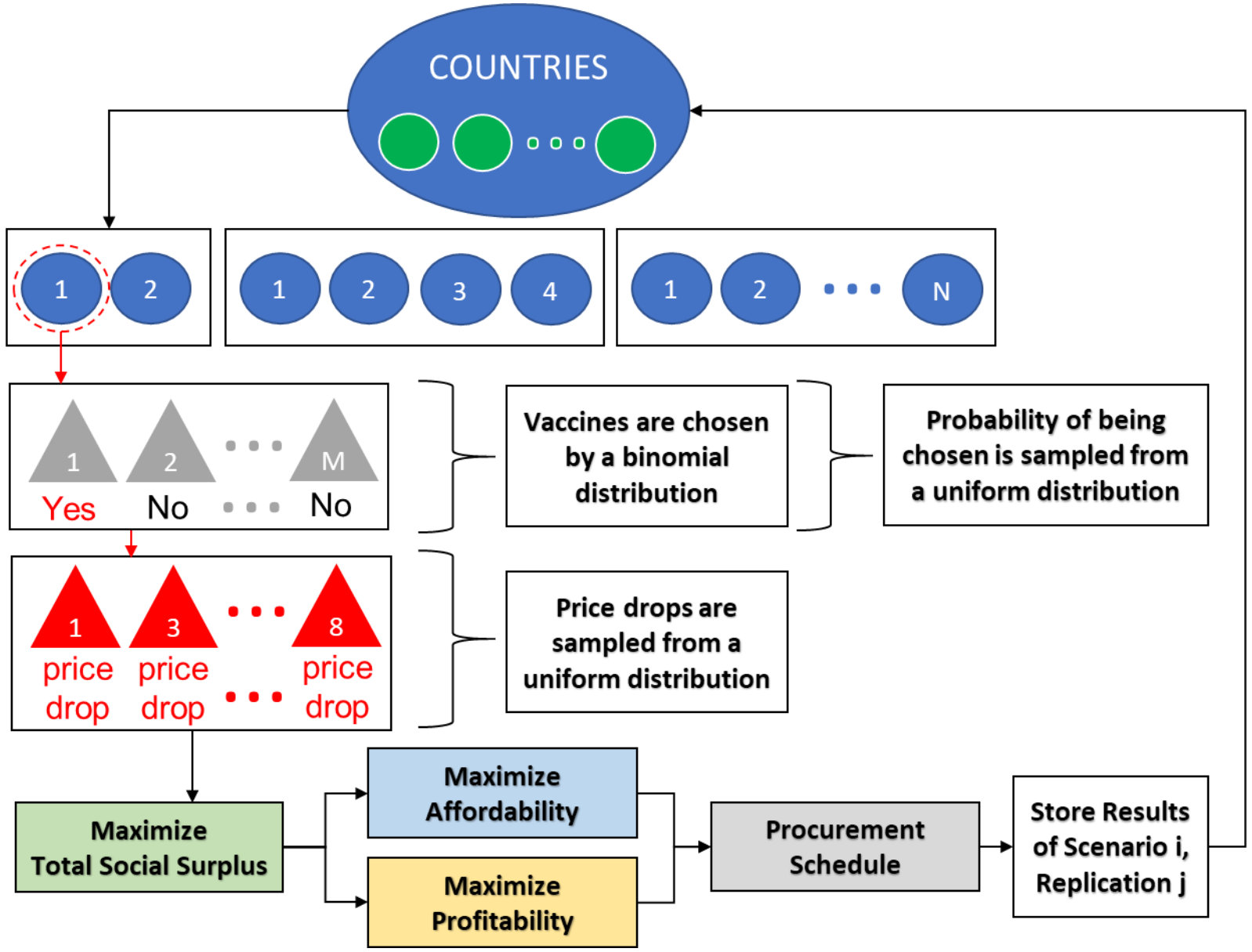
Reservation Price

Pick a market segmentation & pick a market that will face the effects of budget reduction

Pick which vaccines will experience a price drop due to budget reduction

Pick the reduction in reservation price for each of the chosen vaccines

Solve the ABP for this particular instance



Methods

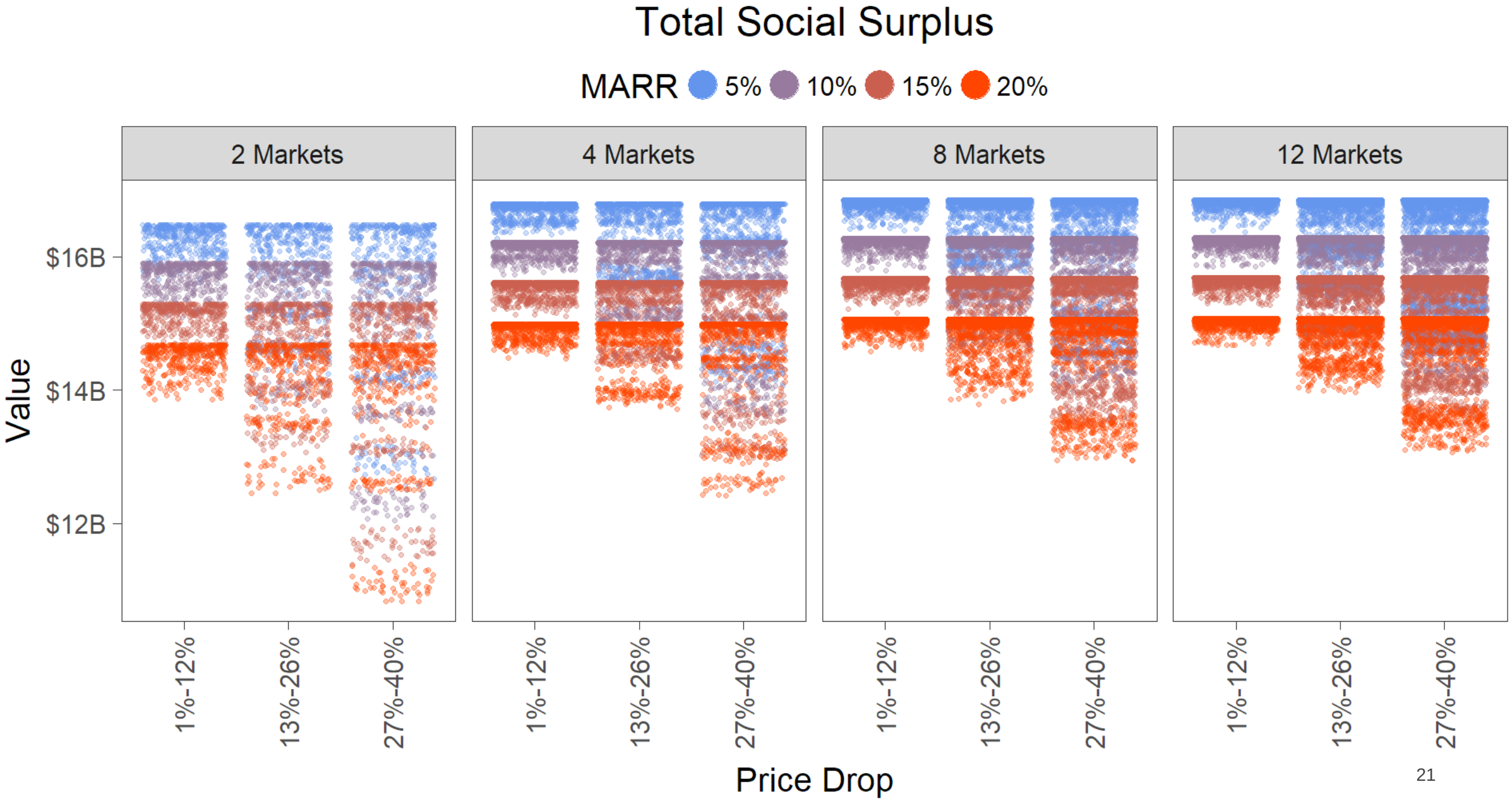
Reservation Price – My Specific Experiment

- Repeated General Factorial Design
  - 3 [price drops] *
    4 [vaccine portions] *
    4 [MARR rates] *
    26 [markets]
    = 1248 [scenarios]
  - 1248 [scenarios] *
    50 [replications]
    = 62400 [runs]

Results

Reservation Price Method – Total Social Surplus

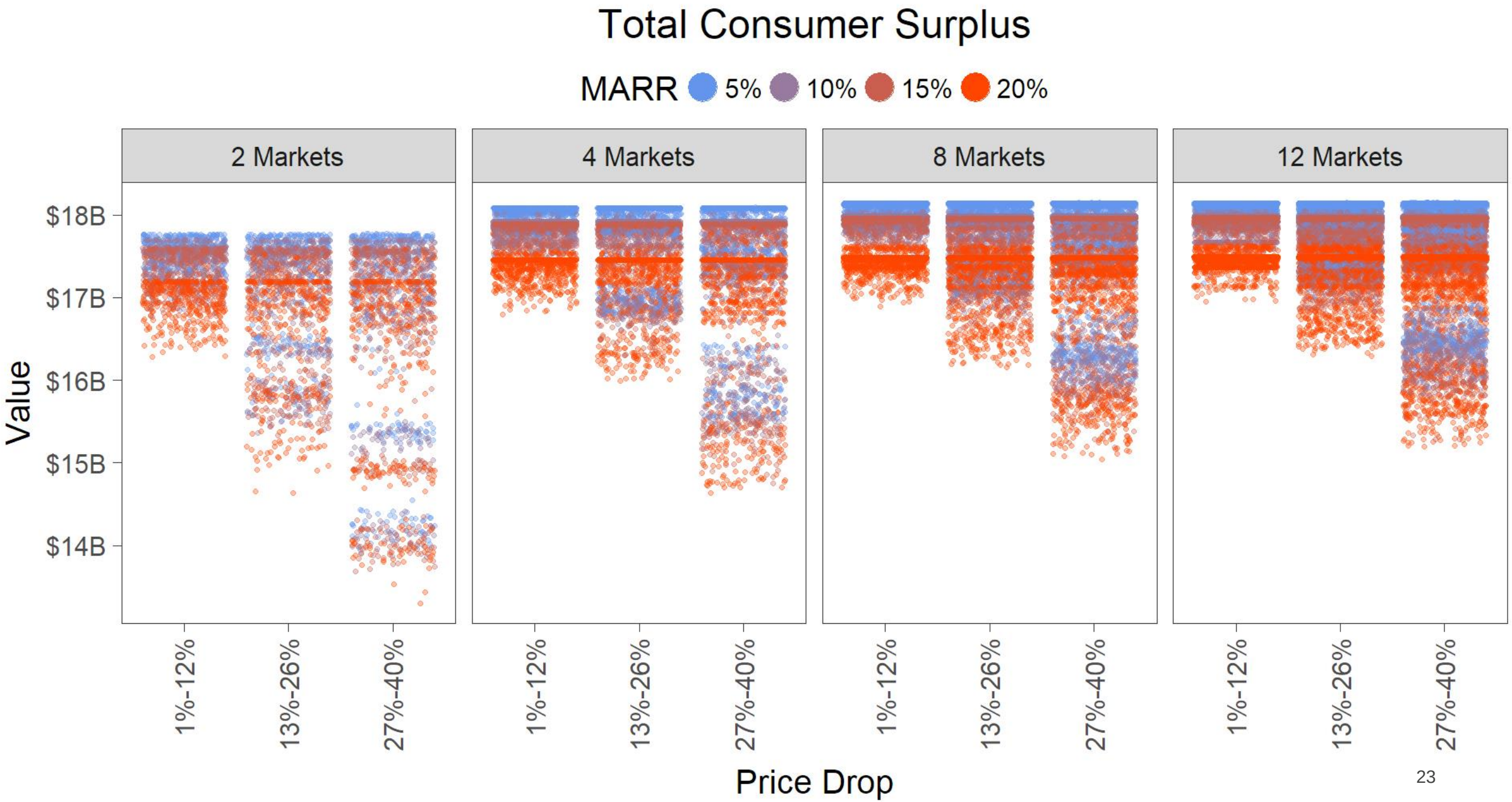
- When countries face a reduction in budget, increasing the market segmentations improves the expected value and variability of total welfare


Total Social Surplus
MARR
5%
10%
15%
20%
2 Markets
4 Markets
8 Markets
12 Markets
Value
$16B
$14B
$12B
1%-12%
13%-26%
27%-40%
Price Drop

Results

Reservation Price Method – Total Consumer Surplus

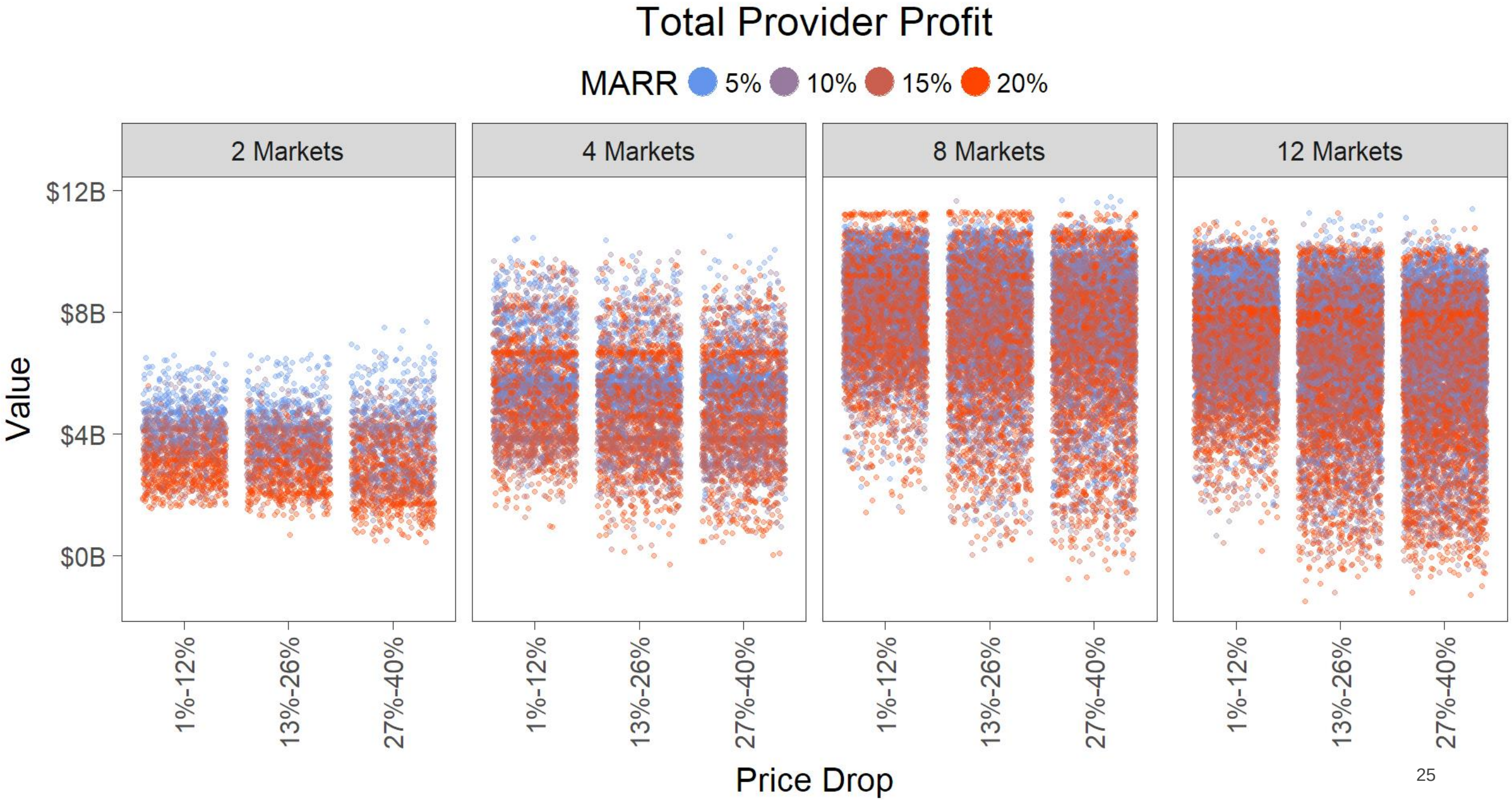
- When countries face a reduction in budget, increasing market segmentations improves the expected value and variability of consumer surplus


Total Consumer Surplus
MARR
5%
10%
15%
20%
2 Markets
4 Markets
8 Markets
12 Markets
Value
$18B
$17B
$16B
$15B
$14B
1%-12%
13%-26%
27%-40%
Price Drop

Results

Reservation Price Method – Total Provider Profit

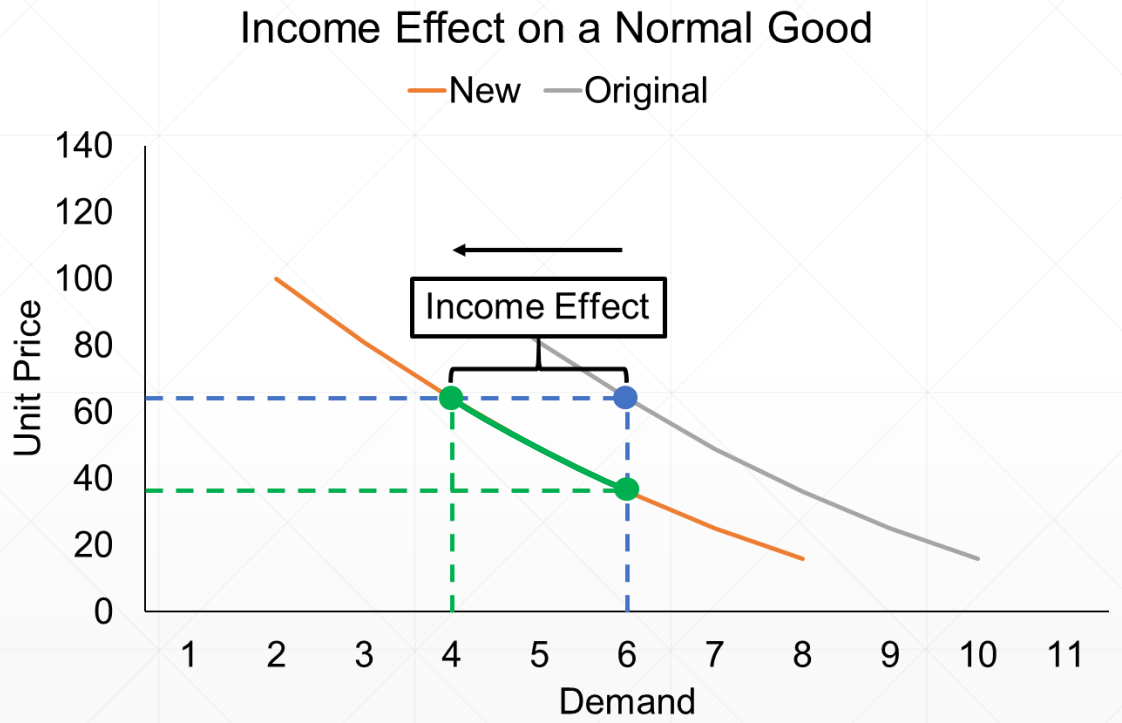
- When countries face a reduction in budget, 8 market segmentations improves the expected value but increases the variability of provider profit
- Provider profit is noisy, harder to estimate


Total Provider Profit
MARR
5%
10%
15%
20%
2 Markets
4 Markets
8 Markets
12 Markets
$12B
$8B
$4B
$0B
Value
1%-12%
13%-26%
27%-40%
Price Drop

Hypothesis

Birth Cohort

- If a country's vaccine budget decreases then the portion of their children that get vaccinated decreases.



Methods

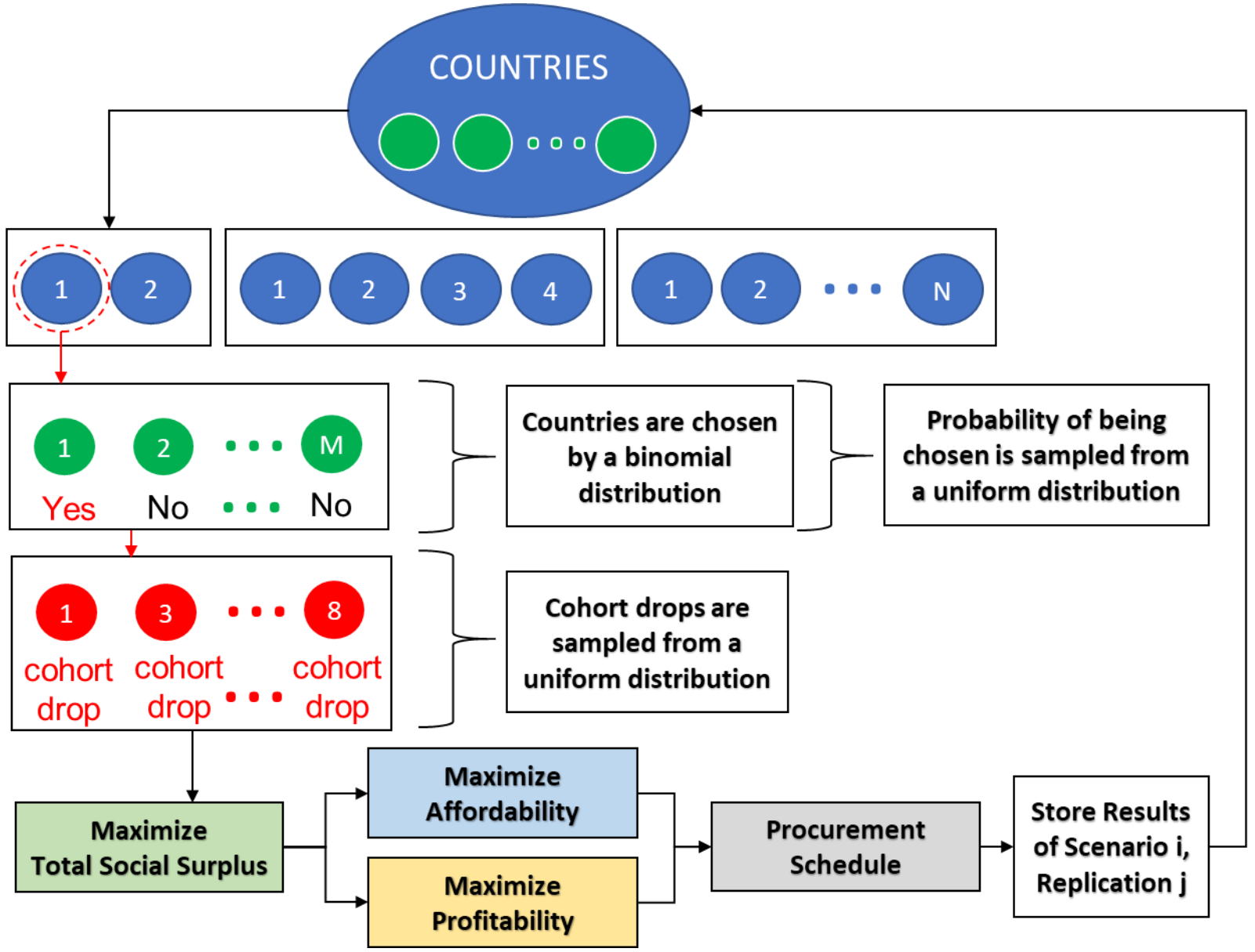
Birth Cohort

Pick a market segmentation & pick a market that will face the effects of budget reduction

Pick which countries will experience a cohort drop due to budget reduction

Pick the reduction in birth cohort for each of the chosen countries

Solve the ABP for this particular instance



Methods

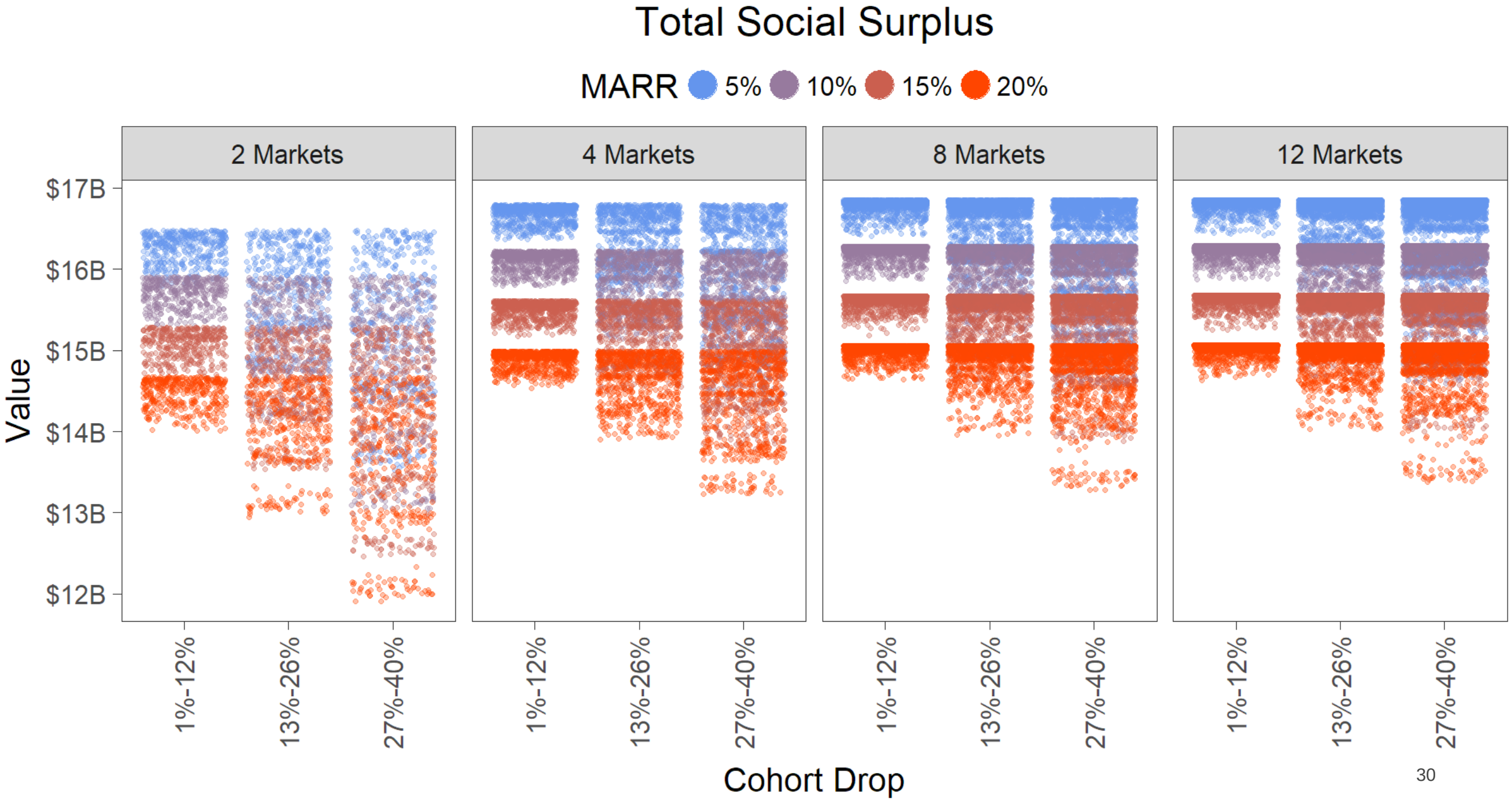
Birth Cohort – My Specific Experiment

- Repeated General Factorial Design
  - 3 [cohort drops] *
    4 [country portions] *
    4 [MARR rates] *
    26 [markets]
    = 1248 [scenarios]
  - 1248 [scenarios] *
    50 [replications]
    = 62400 [runs]

Results

Birth Cohort Method – Total Social Surplus

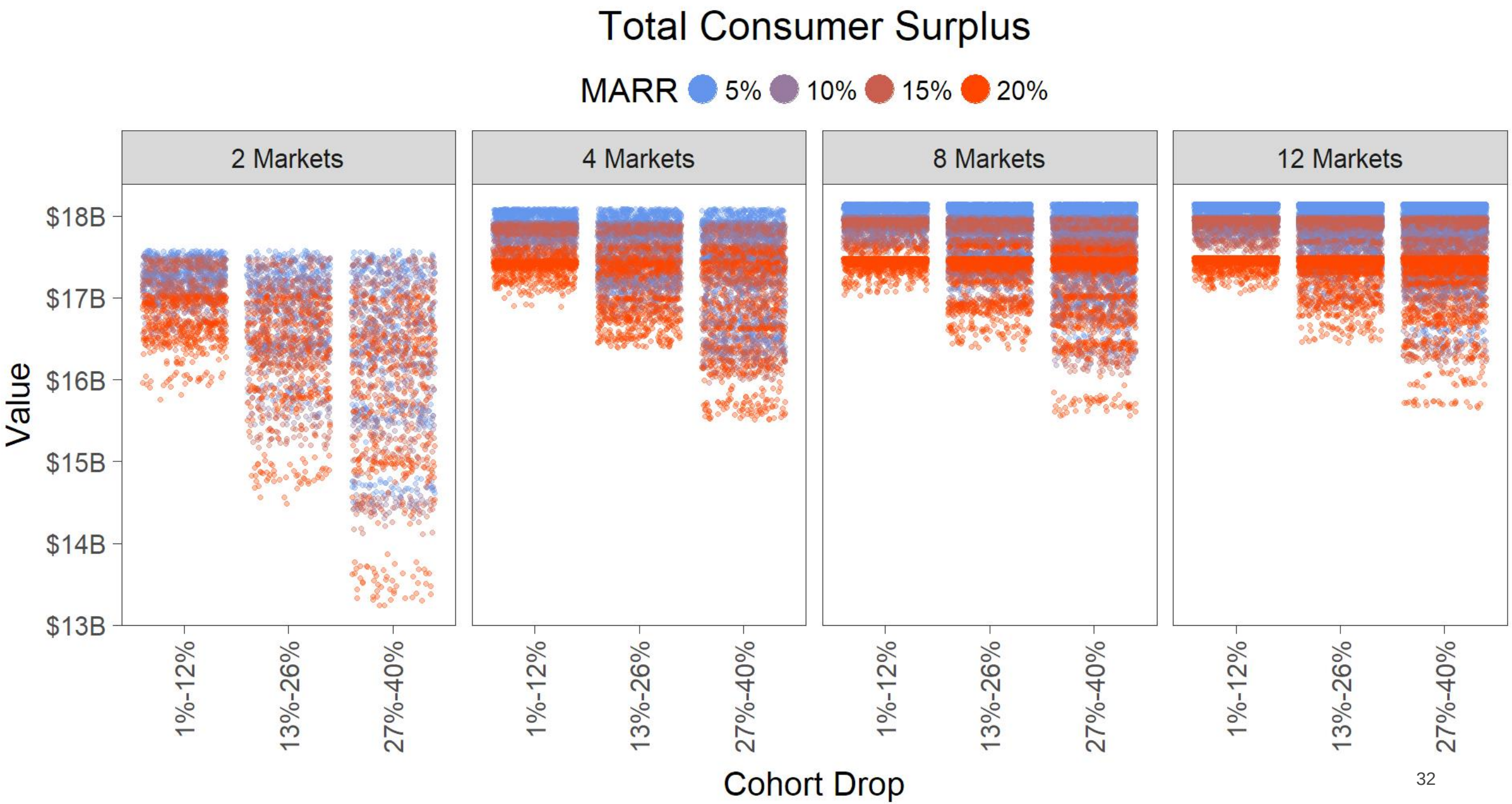
- When countries face a reduction in budget, increasing the market segmentations improves the expected value and variability of total welfare
- The minimum value of total welfare is approximately ½ billion USD larger than in the reservation price method


Total Social Surplus
MARR
5%
10%
15%
20%
2 Markets
4 Markets
8 Markets
12 Markets
$17B
$16B
$15B
$14B
$13B
$12B
Value
1%-12%
13%-26%
27%-40%
Cohort Drop

Results

Birth Cohort Method – Total Consumer Surplus

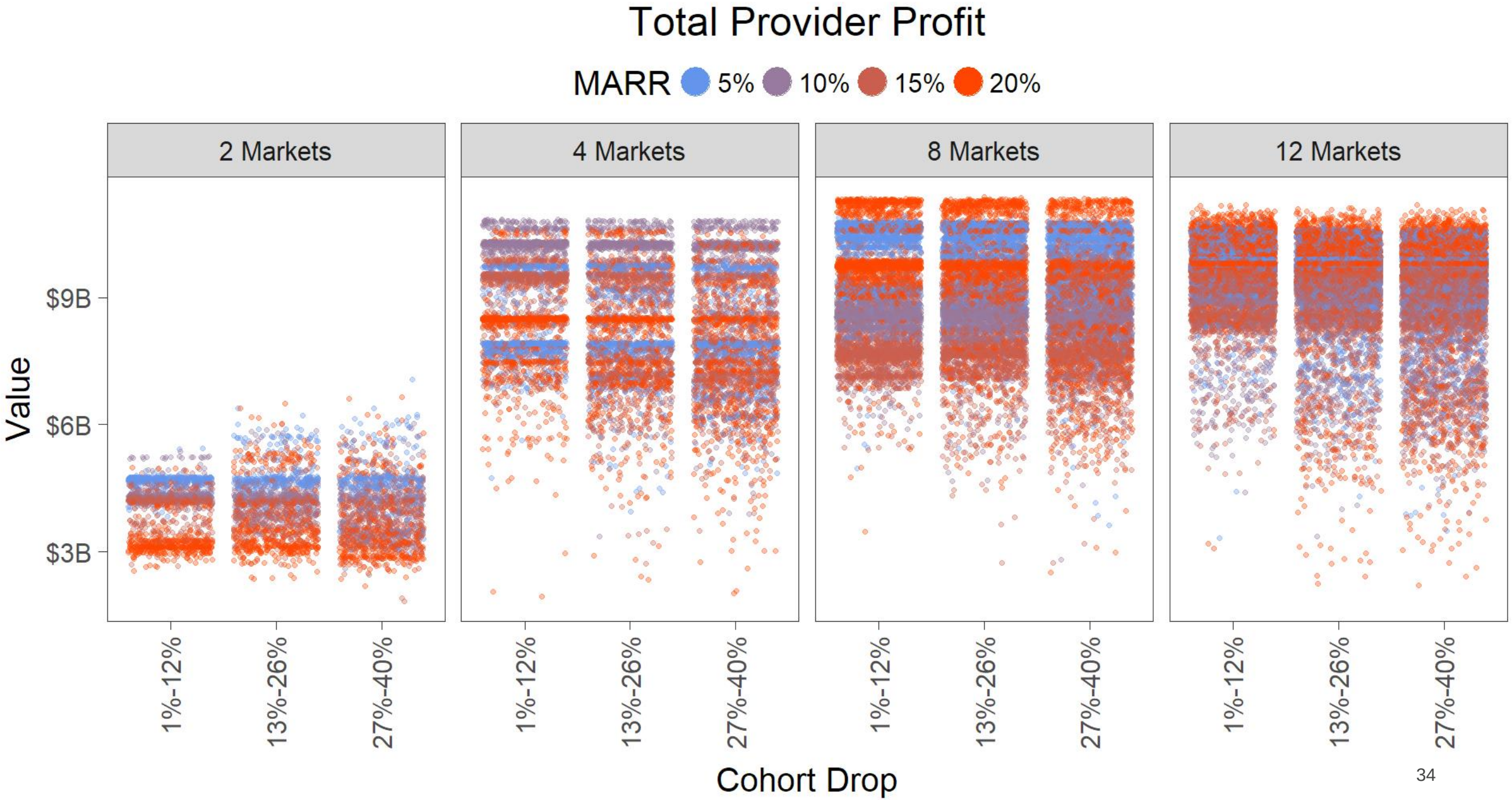
- When countries face a reduction in budget, increasing market segmentations improves the expected value and variability of consumer surplus
- The distribution of consumer surplus is very similar to the reservation price method


Total Consumer Surplus
MARR
5%
10%
15%
20%
2 Markets
4 Markets
8 Markets
12 Markets
Value
$18B
$17B
$16B
$15B
$14B
$13B
1%-12%
13%-26%
27%-40%
Cohort Drop

Results

Birth Cohort Method – Total Provider Profit

- When countries face a reduction in budget, 8 market segmentations improves the expected value but increases the variability of provider profit
- The variability is less than in the reservation price method


Total Provider Profit
MARR
5%
10%
15%
20%
2 Markets
4 Markets
8 Markets
12 Markets
Value
$9B
$6B
$3B
1%-12%
13%-26%
27%-40%
Cohort Drop

Results

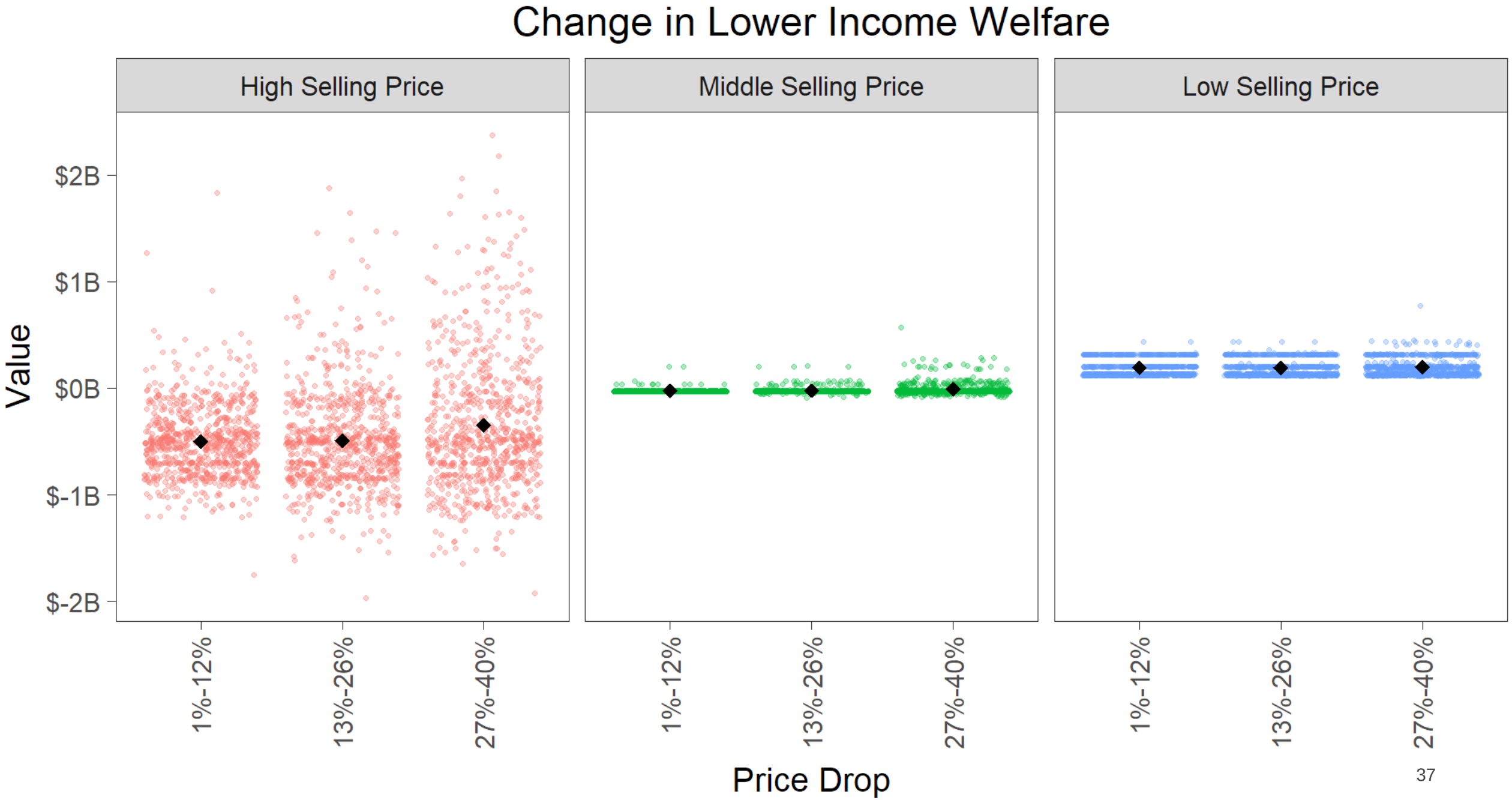
Reservation Price v. Birth Cohort

- Mapping budget uncertainties to birth cohort changes or reservation price changes will both provide similar behavior. However, reflecting budget uncertainties as a birth cohort fluctuations provides results with:
  - 1. Lower variances - Easier to predict
  - 2. Higher Total Social Surplus - Budget uncertainty has less impact
  - 3. Higher Total Consumer Surplus - Budget uncertainty has less impact
  - 4. Higher Total Provider Profit - Budget uncertainty has less impact
  - 5. More balanced market share between providers and consumers - Budget uncertainty has less impact

Results

USA Vaccine Budget – Lower Income Countries

- A reduction in USA vaccine budget can yield up to a ½ billion USD loss in total welfare (-13%) for lower income countries


Change in Lower Income Welfare
High Selling Price
Middle Selling Price
Low Selling Price
Value
$2B
$1B
$0B
$-1B
$-2B
1%-12%
13%-26%
27%-40%
Price Drop

Conclusions

What have we learned?

- Increasing market segmentations continues to show better results for the ABP
- We have developed a framework to implicitly explore the effects of budget uncertainty in a coordinated vaccine market without explicating stating the budget value
- As the price paid for vaccines continues to become more transparent across countries, developing an explicit estimate of vaccine budget on a country level becomes possible
- Risk of budget uncertainty may not be best represented by reservation price or birth cohort, and there is growing availability of public data on countries that could be used for a data mining exercise

Questions?

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References

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- Global Vaccine Action Plan Secretariat Annual Reports 2012-2016 [2]
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