Provider Selection Framework for Bundled Payments in Healthcare Services

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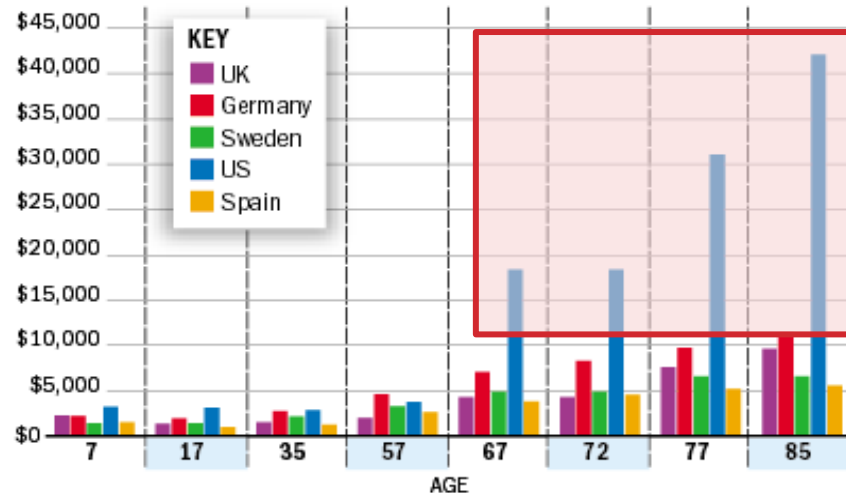
AMCIS 2020

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Motivation

The U.S. healthcare system faces **high costs** and **inconsistent quality.**

Health care costs: U.S. spends more for elderly

Annual per capita healthcare costs by age

KEY
- UK
- Germany
- Sweden
- US
- Spain

Source: Paul Fischbeck, Carnegie Mellon University   James Hilston/Post-Gazette
2011

Because Fee-for-Service (FFS) is **based on Volume not Quality.**
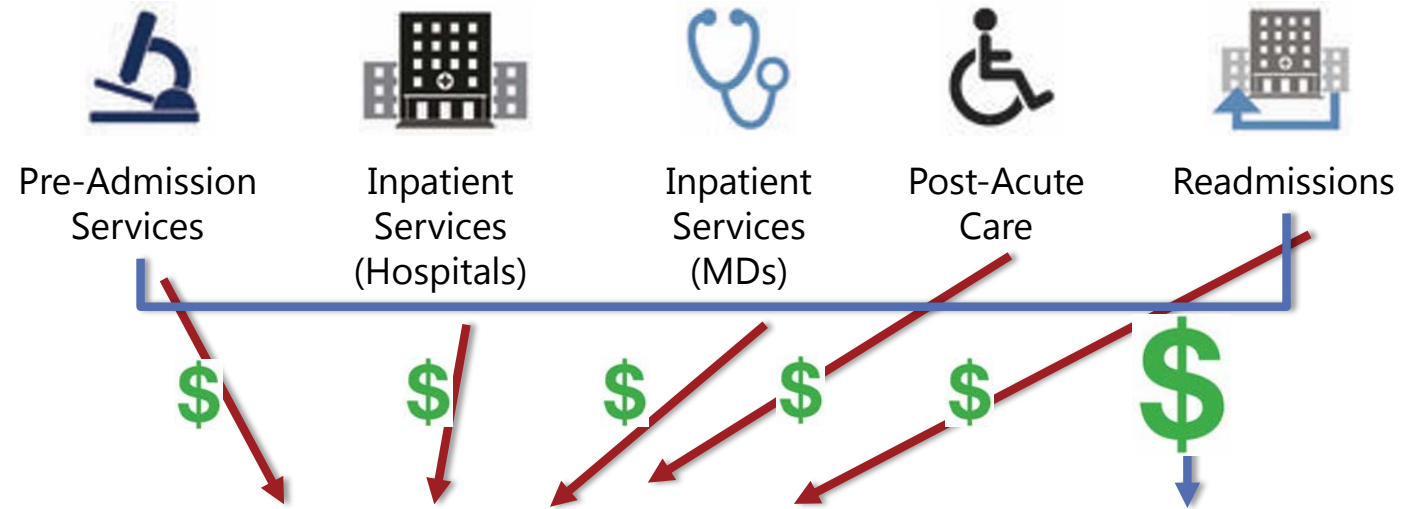
Payment Reform Efforts:

- **Bundled Payments**
- Pay-for-Performance
- Shared Savings
- Accountable Care Organization (ACO)

What is Bundled Payments (BP)?

Single payment for a group of services related to a treatment or condition that may involve multiple providers in multiple settings.

Total Knee Replacement Surgery

Pre-Admission Services

Inpatient Services (Hospitals)

Inpatient Services (MDs)

Post-Acute Care

Readmissions

$ $ $ $ $ $

Traditional Fee-for-Service

|		
1.	Consultation	$200
2.	Anesthesia	$1,259
3.	Surgery	$3,500
4.	Implants	$4,500
5.	Physical Therapy	$925
6.	Recovery Rm, Hospital	$16,000

...

Bundled Payment

Total $26,384

"Target Price"

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Do Bundled Payments (BP) perform better than FFS?

❑ **Evaluation Reports: Year 1 (CMS 2015) ~ Year 6 (CMS 2020)**

Location of BPCI Participants, by Medicare CBSA

# of BPCI Providers

Non-BPCI Area · 1-5
6-14 · 15+
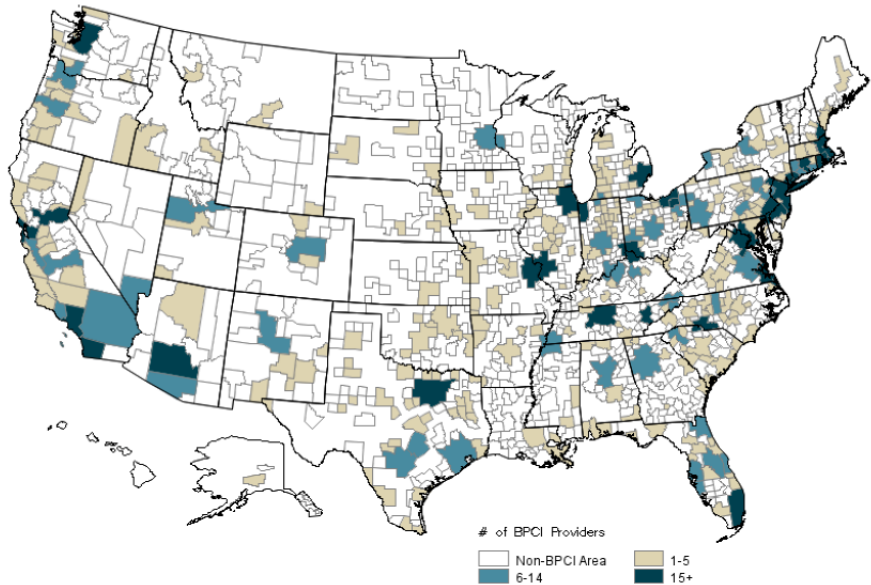
▪ **Changes in Payments**:
  - **Insignificant** for the most of bundled episodes.
  - Limited evidence of savings.

▪ **Changes in Quality** (Mortality Rate, Readmission Rate):
  - **Insignificant difference** compared to FFS.

▪ **Participant Characteristics**: Majority of participants were
  - **Not-for-profit, in urban locations, larger, and had greater teaching activity**.

❑ **Other studies on Bundled Payments deliver similar insights.**
  - Descriptive and Observational: Hussey et al. (2012, AHRQ) etc.
  - Analytical: Adida et al. (2016, MS), Gupta and Mehrotra (2015, OR)

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Opportunities in BP Provider Selection

- **Negotiation method**
- The Medicare Heart Bypass Center Demonstration (CMS, 1991-1996)

- **Weighted average composite score**

Demonstration design (10%)	Organizational structure and capabilities (20%)	Performance results (35%)	Payment methodology (35%)

- **Acute Care Episode Demonstration** (CMS, 2009-2012)

- **Expert panel evaluation based on relative weights**
- **Bundled Payments for Care Improvement Initiative (BPCI)** (CMS, 2013~)

Additive assumptions introduced in the weights can cause problems in the decision-making process (McCabe et al. 2005).

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Potential Drawbacks in Status Quo Policy

❑ **Suppose a BP using three-dimensional criteria to select providers.**

Efficiency (30%)	Effectiveness (35%)	Expected Savings under BP (35%)

❑ **What if a payer would like to emphasize "Effectiveness" more?**

▪ Increase the weight of Effectiveness.

Efficiency (25%)	Effectiveness (45%)	Expected Savings under BP (30%)

❑ **Do the weight adjustments work?**

▪ Perhaps yes, but not always. Example:

	Previous Weights		Adjusted Weights	
	Hospital A	Hospital B	Hospital A	Hospital B
Efficiency	25	15	20.83	12.50
Effectiveness	**20**	**35**	**25.71**	**45.00**
Expected Savings	35	20	30.00	17.14
Total Score	**80**	70	**76.54**	74.64

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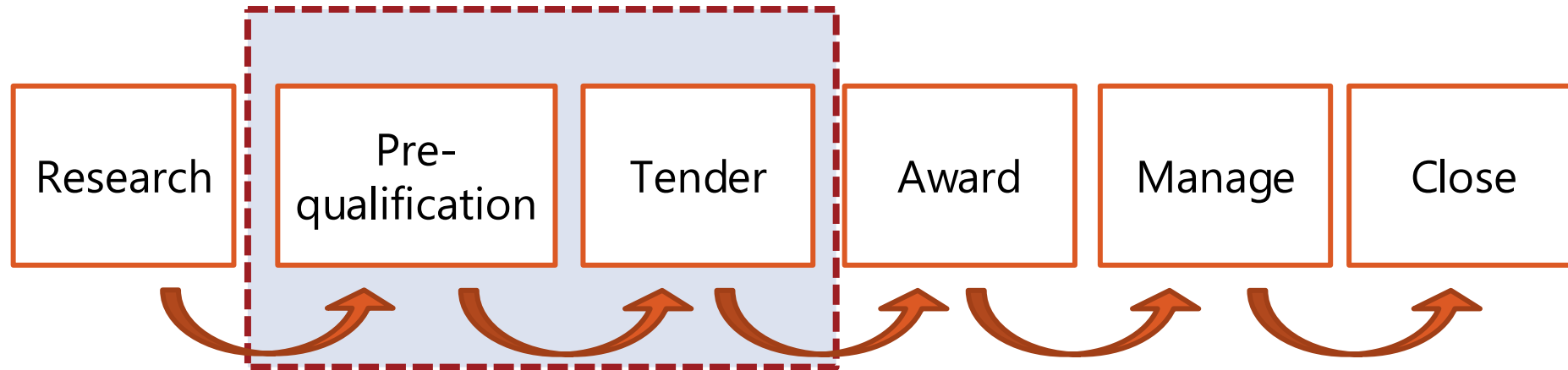
Research Question

How can a payer select providers to operate bundled payments while **balancing a multitude of evaluation criteria?** (e.g., efficiency, effectiveness, expected savings)
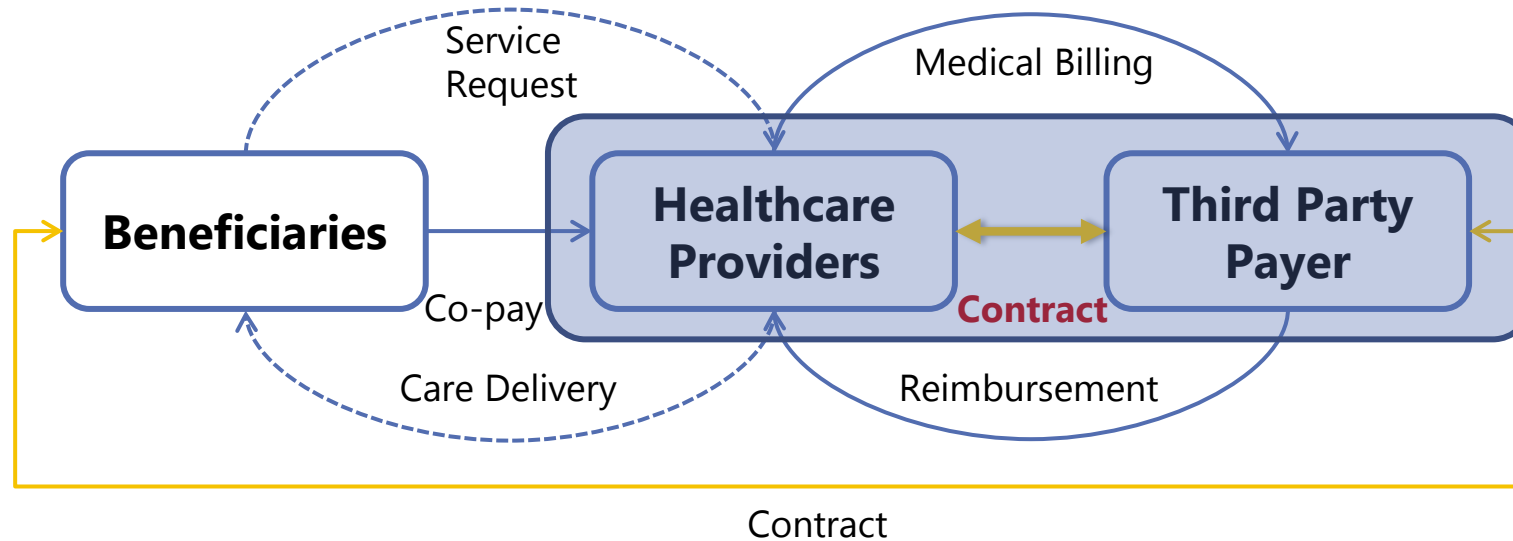
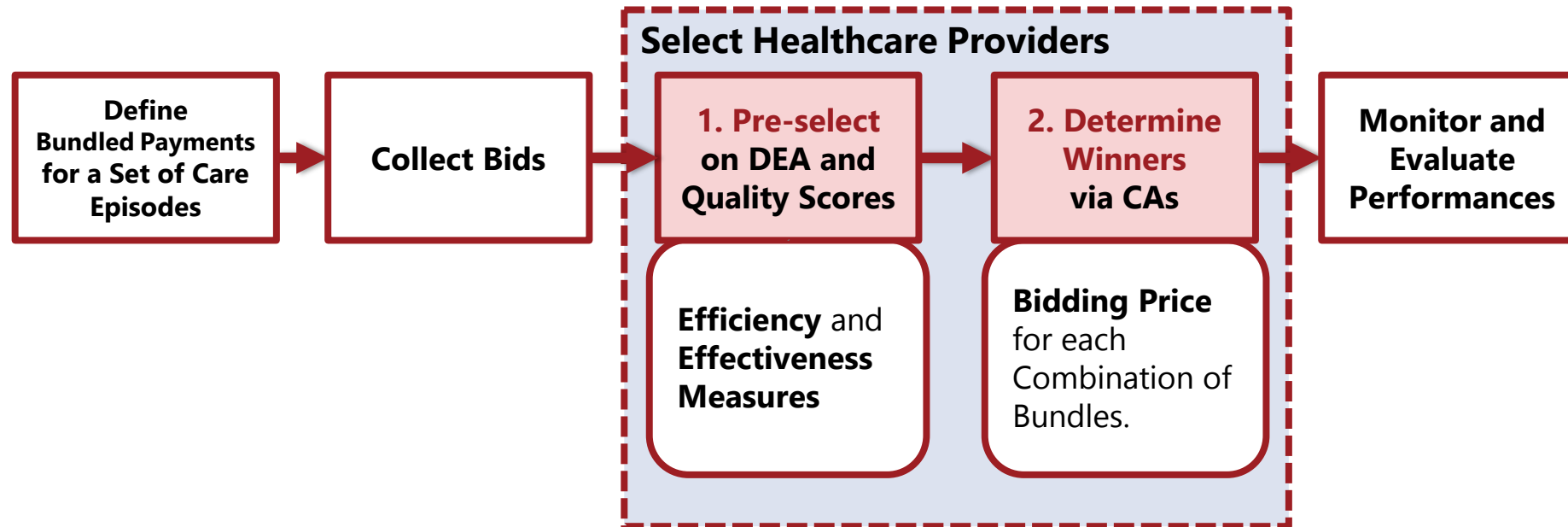A triadic view of the healthcare delivery system (Lee et al. 2016)

Provider Selection and Management Literature

| Research | Pre-qualification | Tender | Award | Manage | Close |

❑ **Pre-qualification** seeks to reduce a list of providers.

- ▪ e.g., production capacity of the provider, willingness to tender, financial stability, and technical experience.

❑ **Supplier (or Vendor) Selection Problem in SCM**

- ▪ Analytic Hierarchy Process (e.g., Liu and Hai 2005),
- ▪ Mathematical Programming (e.g., Ng 2008)
- ▪ Analytic Network Process (e.g., e.g., Gencer and Gurpinar 2007)

A Framework for BP Provider Selection

❑ In a **Payer's** Perspective (e.g., CMS),

Select Healthcare Providers

| Define Bundled Payments for a Set of Care Episodes | → | Collect Bids | → | 1. Pre-select on DEA and Quality Scores | → | 2. Determine Winners via CAs | → | Monitor and Evaluate Performances |

1. Pre-select on DEA and Quality Scores — **Efficiency** and **Effectiveness Measures**

2. Determine Winners via CAs — **Bidding Price** for each Combination of Bundles.

1. Pre-select Providers: Efficiency and Effectiveness
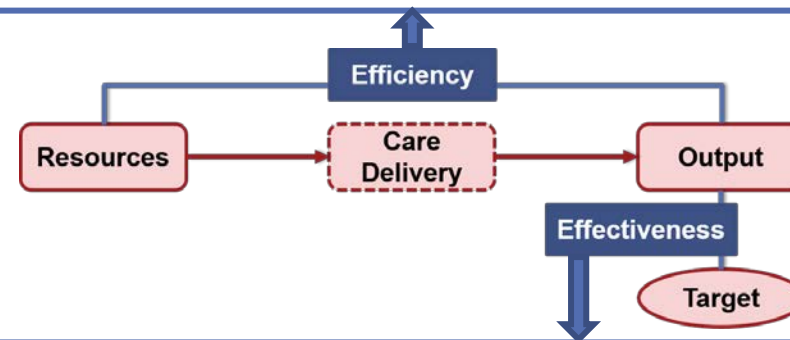
Efficiency: Data Envelopment Analysis (DEA)

- **Inputs**
    - Number of Operational Beds
    - Service Complexity
    - Full Time Equivalents
    - Other Operational Expenses

- **Outputs**
    - Case-mix Adjusted Discharges
    - Outpatient Visits

Effectiveness: Quality Measures by CMS

- 30-Day Readmission Rate
- 30-Day Mortality Rate

- Patient Satisfaction Score

2. Determine Winners via Combinatorial Auction (CA)

❑ Based on **bidding prices** suggested by providers.

Bundled Payment Program

	Bundle 1	Bundle 2	Bundle 3	Bundle 4	# of Bidding Options
Potential Participants					
Provider **A**	✓				1
Provider **B**			✓	✓	3
Provider **C**	✓	✓	✓	✓	15

❑ CA reflects preferences and capabilities of each Provider.

Combinatorial Auction: Settings

☐ **Objective**

- Maximize Discounted Amount compared to FFS.

☐ **Subject to**

- Efficiency and Quality Scores
- Min Required Capacity of Healthcare Providers
- Min/Max # of Winners in each Region
- Demand

☐ **Auction Settings**

- Single Price Bid / First Price Sealed Bid
- Multiple Winners Available
- Each Bundle is a Single Unit (all-or-nothing bid)

Combinatorial Auction: Formulation

Weighted Composite Score:

$$\sum_{i \in N} \left(\alpha \sum_{j \in M} (\bar{p}_{ij} - p_{ij}) x_{ij} + \beta E_i y_i + \gamma Q_i y_i \right)$$

Combinatorial Auction:

Discounted Amount   Efficiency Score   Quality Score

Maximize $\quad \sum_{i \in N} \sum_{j \in M} (\bar{p}_{ij} - p_{ij}) x_{ij}$

Subject to
$$E_i y_i \geq \sigma_g, \quad \forall i \in N, \ \forall g \in G$$
$$Q_i y_i \geq \epsilon_g, \quad \forall i \in N, \ \forall g \in G$$

$$\sum_{i \in N} \sum_{j \in M} a_{ij}^k x_{ij} \geq 1, \quad \forall k \in K,$$

$$\sum_{j \in M} x_{ij} \leq y_i, \quad \forall i \in N,$$

Bid Coverage, Provider Selection

$$W_{r,min}^k y_i l_{ir} \leq c_i^k, \quad \forall r \in R, \forall k \in K, \ \forall i \in N,$$

Min Capacity

$$S_{r,min}^k \leq \sum_{i \in N} \sum_{j \in M} l_{ir} a_{ij}^k x_{ij}, \quad \forall r \in R, \ \forall k \in K,$$
$$S_{r,max}^k \geq \sum_{i \in N} \sum_{j \in M} l_{ir} a_{ij}^k x_{ij}, \quad \forall r \in R, \ \forall k \in K,$$

Min/Max Winners in each Region

$$D_{r,min}^k \leq \sum_{i \in N} \sum_{j \in M} l_{ir} a_{ij}^k c_i^k x_{ij}, \quad \forall r \in R, \ \forall k \in K,$$

Demand

i: Hospital
j: Bid Combination
g: Subset ID
k: Care Bundle
r: Region

$$x_{ij} \in \{0, 1\}, \quad \forall i \in N, \ \forall j \in M,$$

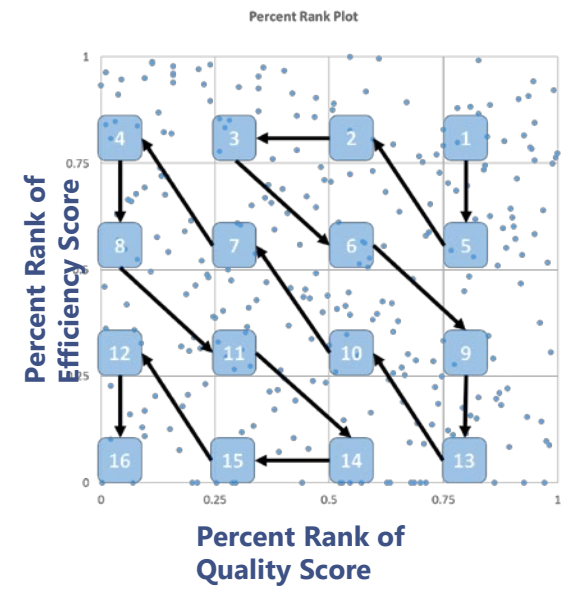$$y_i \in \{0, 1\}, \quad \forall i \in N$$

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How the Pre-selection Works

❑ **Efficiency Score vs. Quality Score**

Percent Rank Plot

Worst Provider

Top Provider

Percent Rank of Efficiency Score
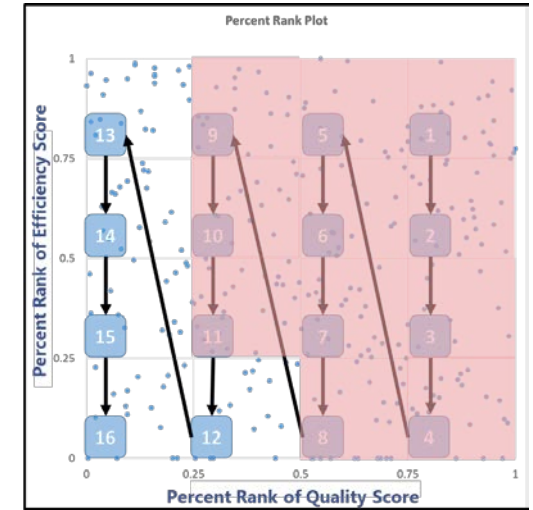
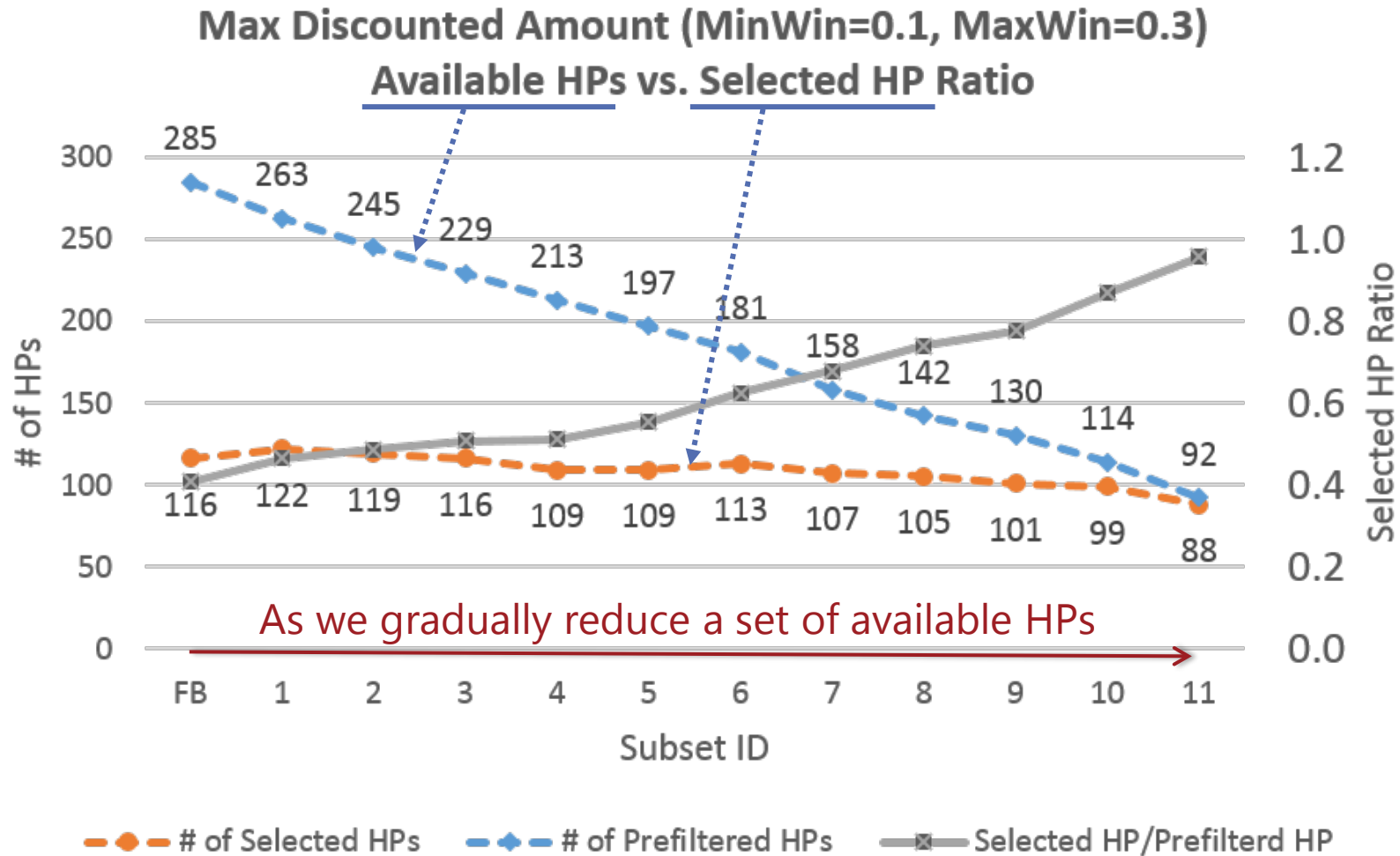Percent Rank of Quality Score
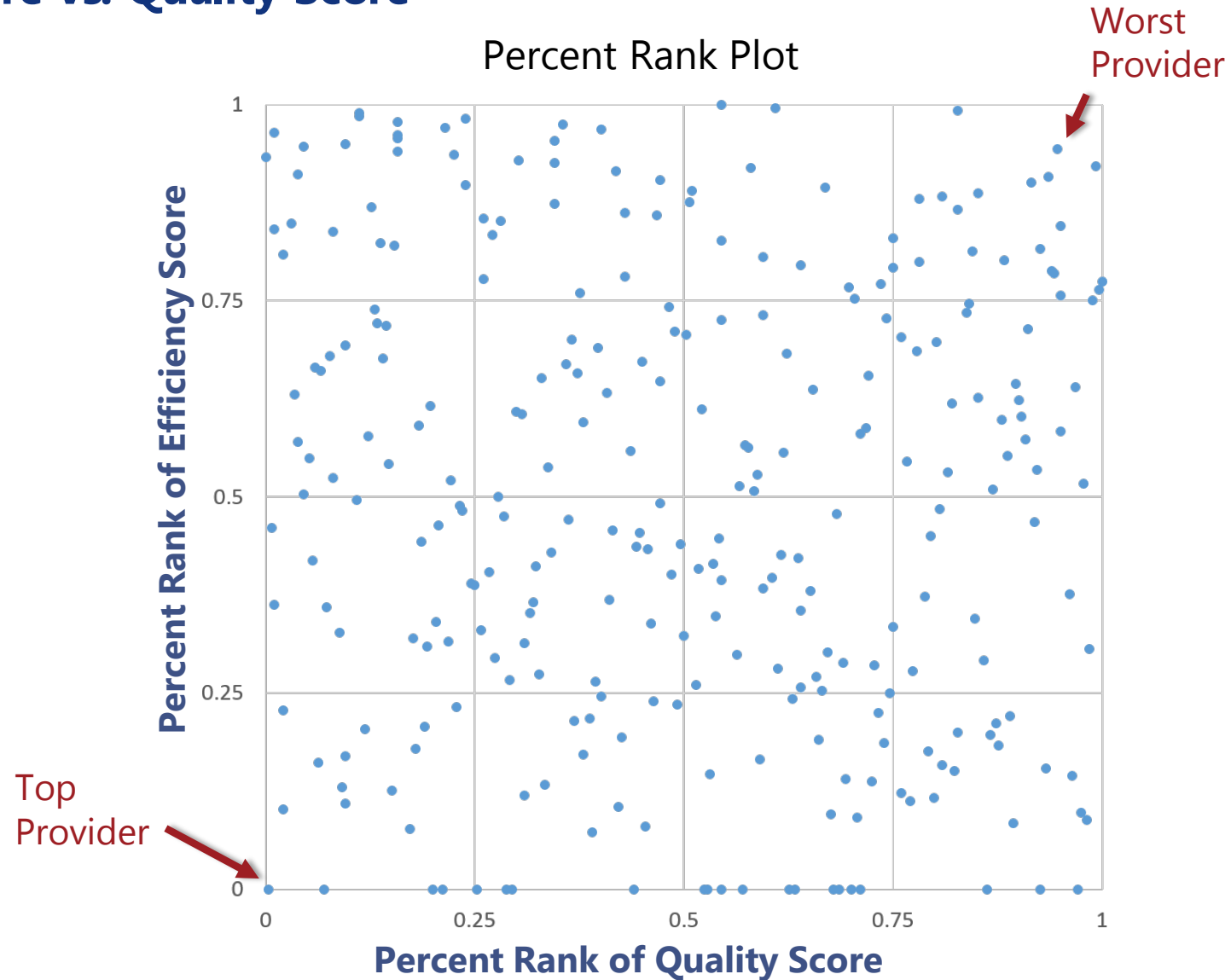
How the Pre-selection Works
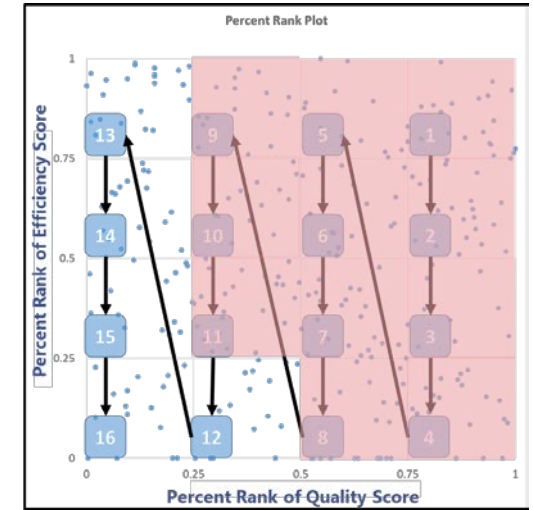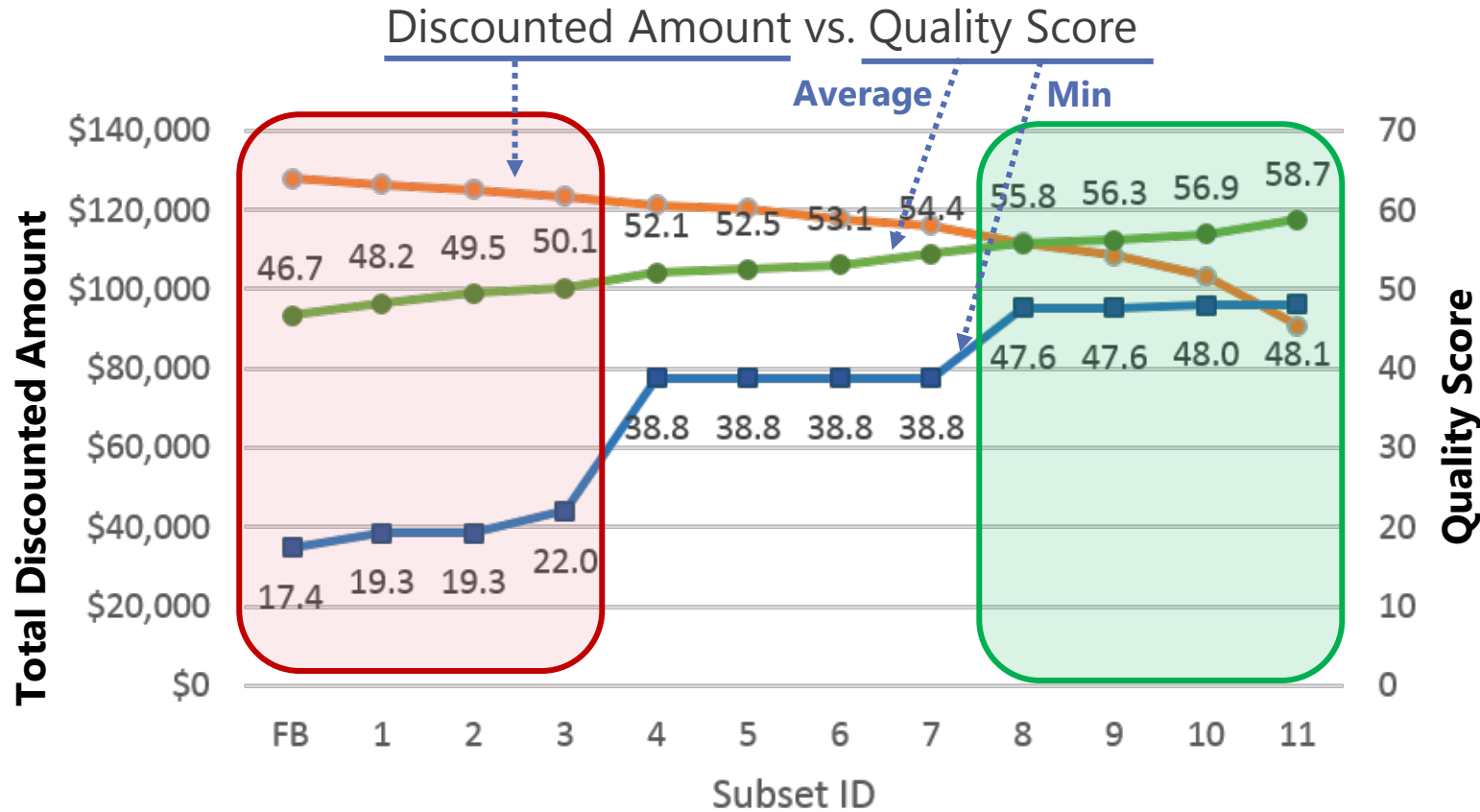
❑ **Iteratively reduce feasible regions** while running auction model.
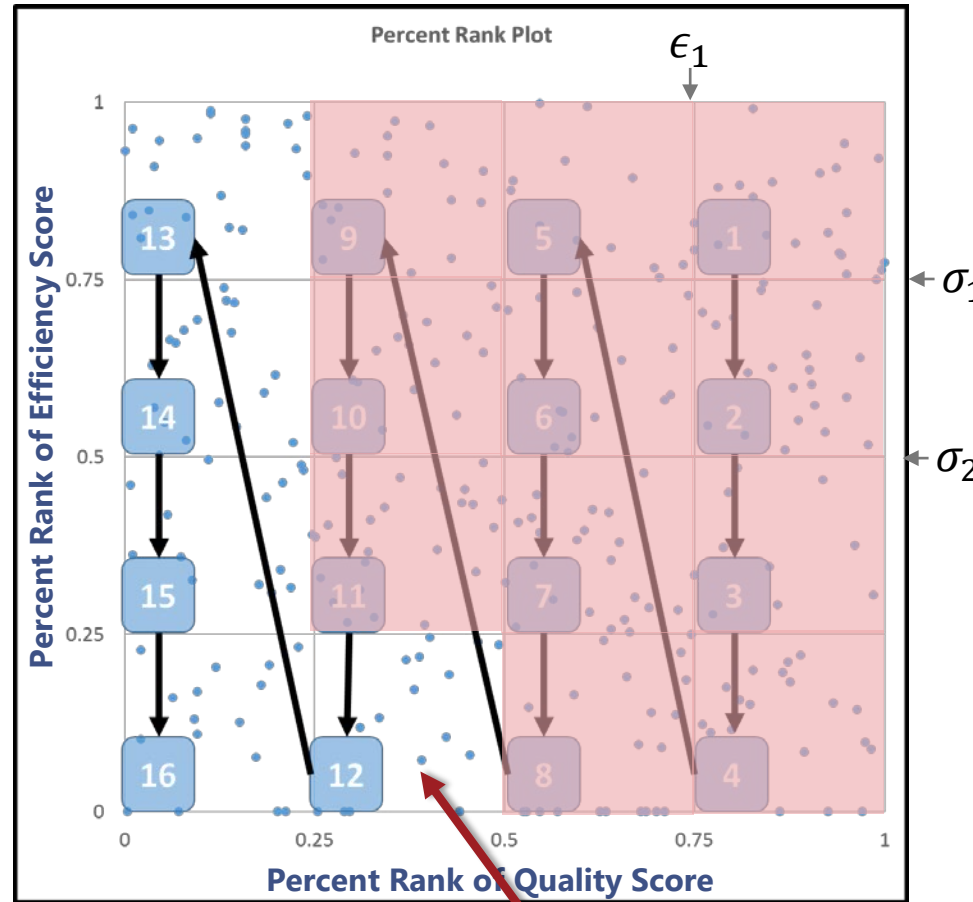
Cannot derive a winner group if this region is removed. Stop. (e.g., Min # of winners in each region is not satisfied)

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Results of Selection Practice

Max Discounted Amount (MinWin=0.1, MaxWin=0.3)
Available HPs vs. Selected HP Ratio

As we gradually reduce a set of available HPs

Legend:
- ● # of Selected HPs
- ◆ # of Prefiltered HPs
- ✖ Selected HP/Prefilterd HP

Axis labels: # of HPs (left), Selected HP Ratio (right), Subset ID (x-axis)

Data points (# of Prefiltered HPs): 285, 263, 245, 229, 213, 197, 181, 158, 142, 130, 114, 92

Data points (# of Selected HPs): 116, 122, 119, 116, 109, 109, 113, 107, 105, 101, 99, 88

Subset IDs: FB, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

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Results of Selection Practice

Discounted Amount vs. Quality Score

A Payer can selectively decides winner groups with balancing **bid prices** and **their performance.**

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Comparison with Status-Quo Policy

Reduced Pre-filtered HPs →

	Weighted Average Method			HP Selection Framework		
	0.3*	0.2*	0.1*	4**	8**	11**
# of Selected HPs	112	87	52	109	105	88
Sum of Discounted Amount	82420.96	62124.82	35878.43	120663.52	99297.58	85079.13
Average of Quality Score	53.53	54.05	55.44	52.10	55.80	58.70
Min of Quality Score	27.13	27.13	34.05	38.80	47.60	48.10
Average of Efficiency Score	0.57	0.62	0.70	0.49	0.46	0.50
Min of Efficiency Score	0.09	0.09	0.12	0.09	0.07	0.09

Boxplot of Quality Score
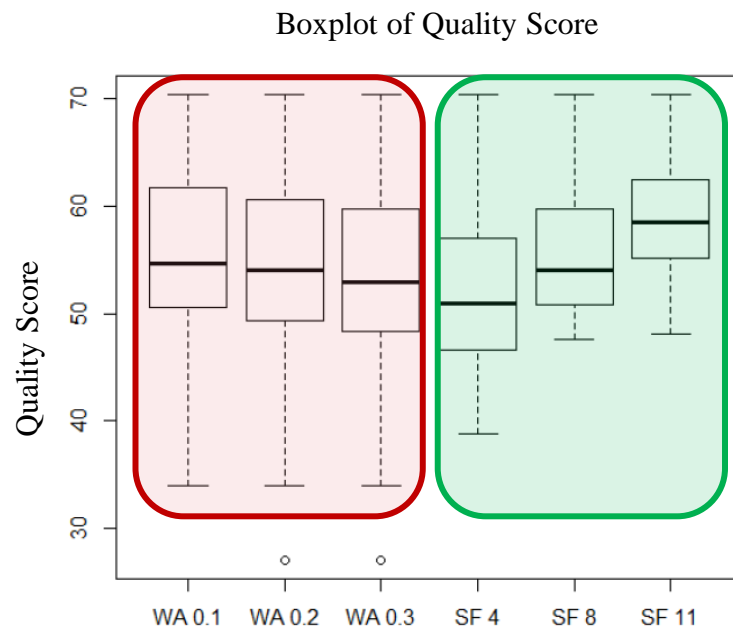
- ❑ **Weighted Average Method**
  - ▪ Indifferent quality distribution of selected providers.

- ❑ **Proposed Framework**
  - ▪ Improvement in quality scores.
  - ▪ Maximized potential savings under BP.

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Comparison with Status-Quo Policy

❑ **Visualization of Winner Determination**

303 providers in TX
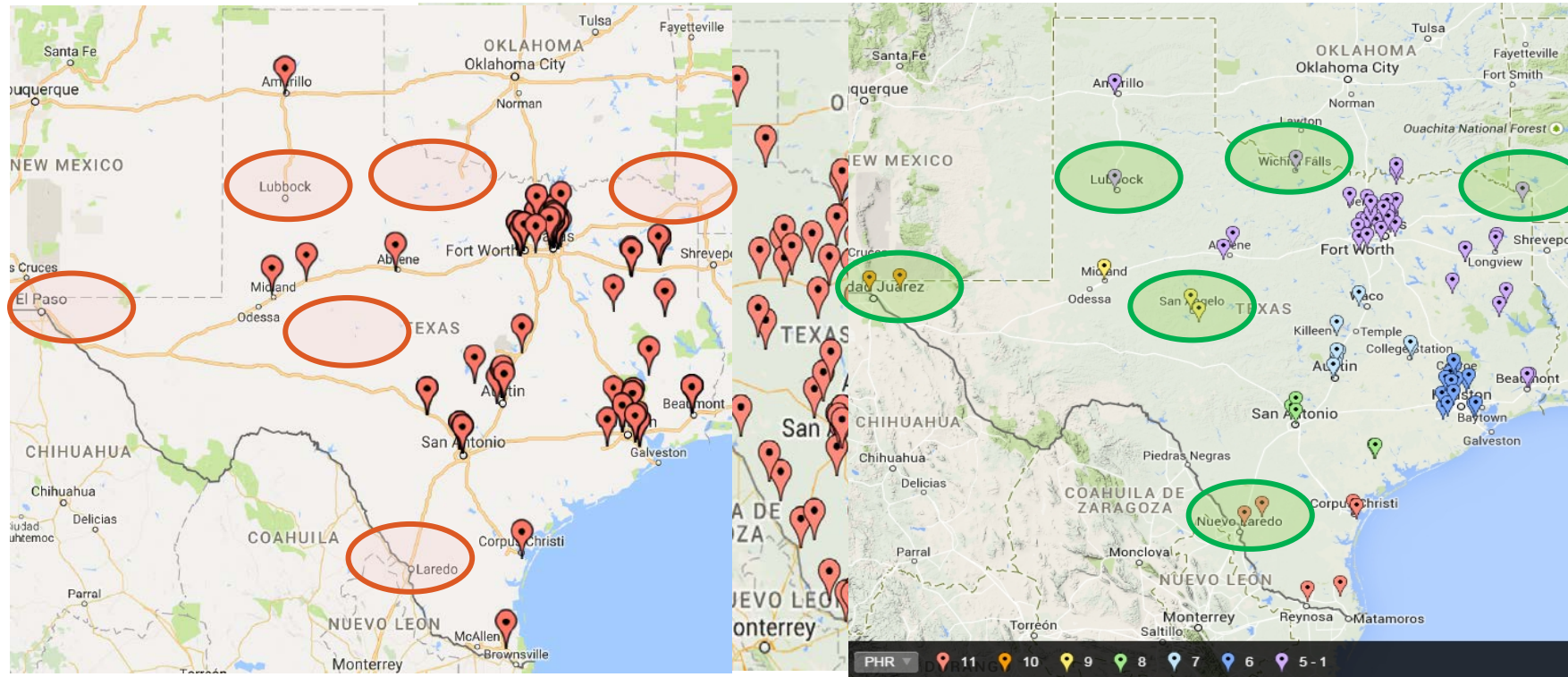
CMS BPCI Initiative Participants: 50 providers

Example Results of Our Selection Framework: 88 providers

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Implications

❑ **Bundled payment programs transfer a portion of financial responsibilities from a payer to the providers.**

- Providers become strategic in determining "target price" of bundles.

❑ **Current provider selection practice may fail in achieving simultaneous cost reduction and quality improvement.**

- Weighted averaged score leads to suboptimal performance.
- Winner determination after pre-selection may be a solution.

❑ **Combinatorial auction effectively manages the geographical constraint and providers' preference.**

- Applicable for other payment reform models.

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Q & A

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