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Estimating the technical efficiency of immunization programs:

Evidence from the EPIC studies

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Motivation

- Research on health service delivery costs commonly show substantial variation between sites
- Large differences in site-level efficiency point to the potential for efficiency gains through program intervention
- Understanding how efficiency correlates with site characteristics can provide information on types of sites operating less efficiently

Research questions

- On average, how efficient is the typical routine immunization site when compared to sites on the efficient frontier?

- To what extent are differences in efficiency attributable to observable site characteristics? What types of sites represent high potential for efficiency gains?

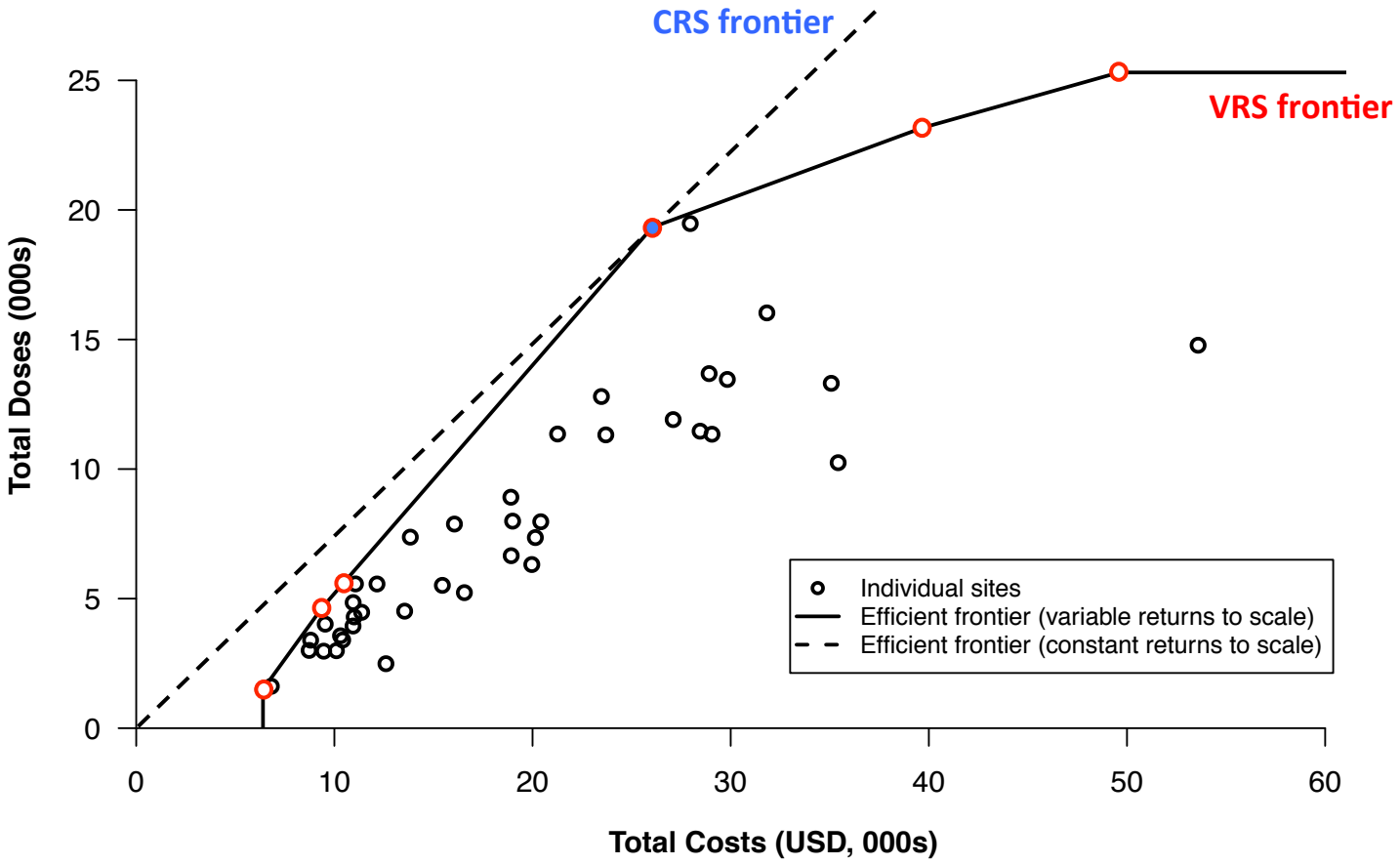
- Is it possible to define a restricted set of performance measures that could be used to assess efficiency as part of routine program management?

→ **This for later**

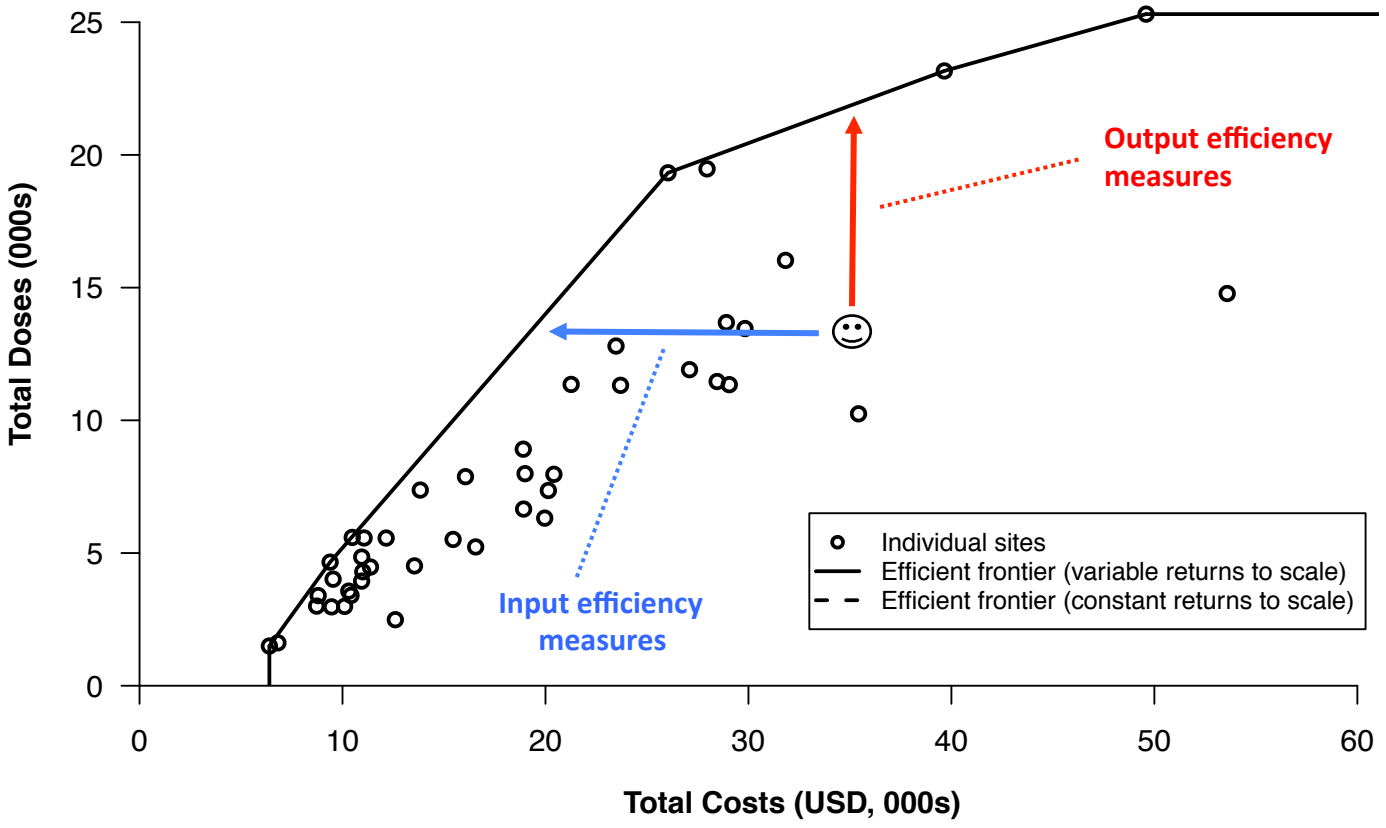
Data envelopment analysis

- Linear programming approach: defines efficient frontier based on available sample of sites, compared all sites to this frontier
- Non-parametric approach, relatively weak assumptions about the characteristics of the underlying technology
- Able to consider multiple inputs (e.g. labor, capital) used to produce multiple outputs (e.g. outpatient visits, inpatient consults, inpatient bed days)

DEA – defining the efficient frontier



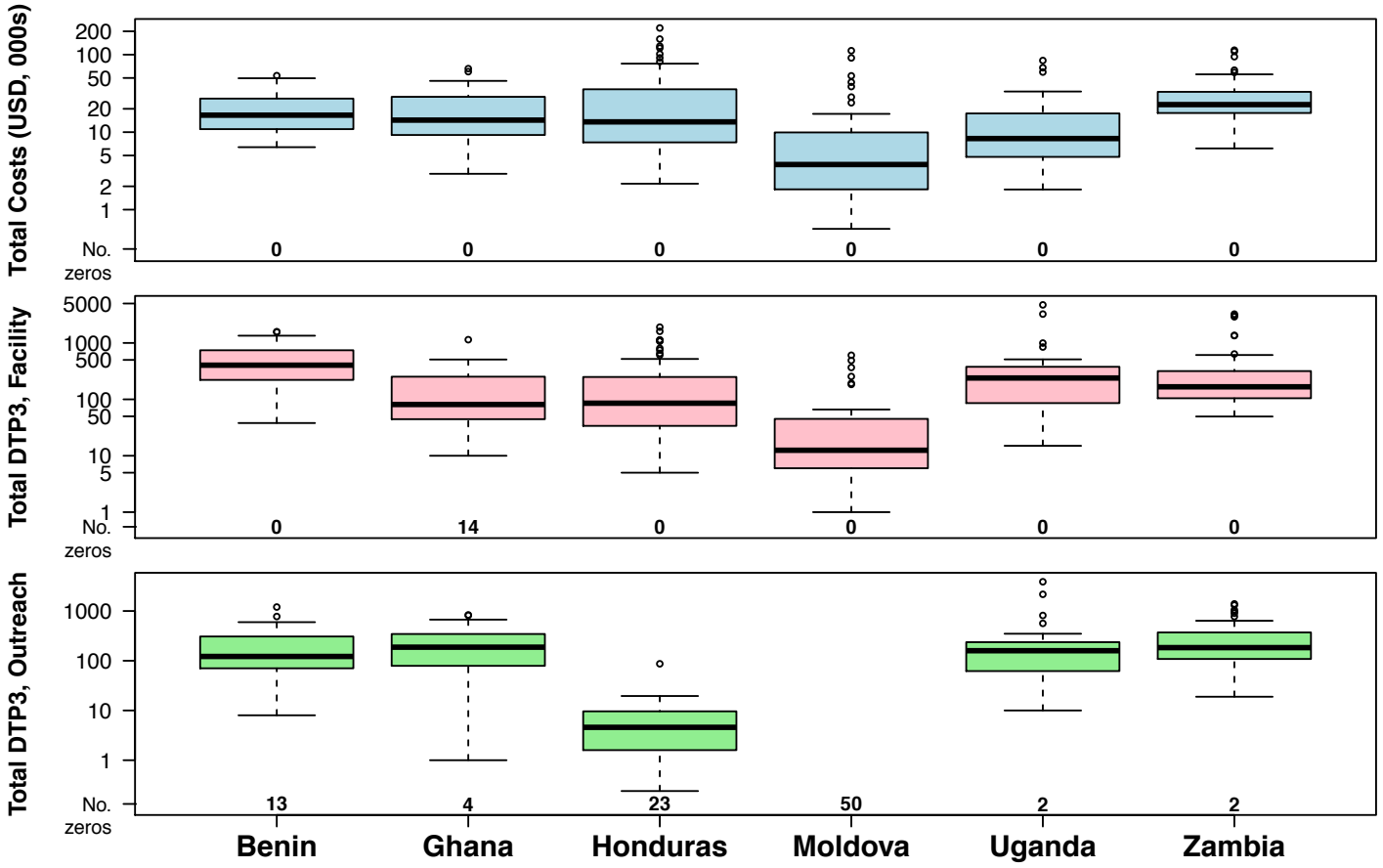
DEA – defining efficiency



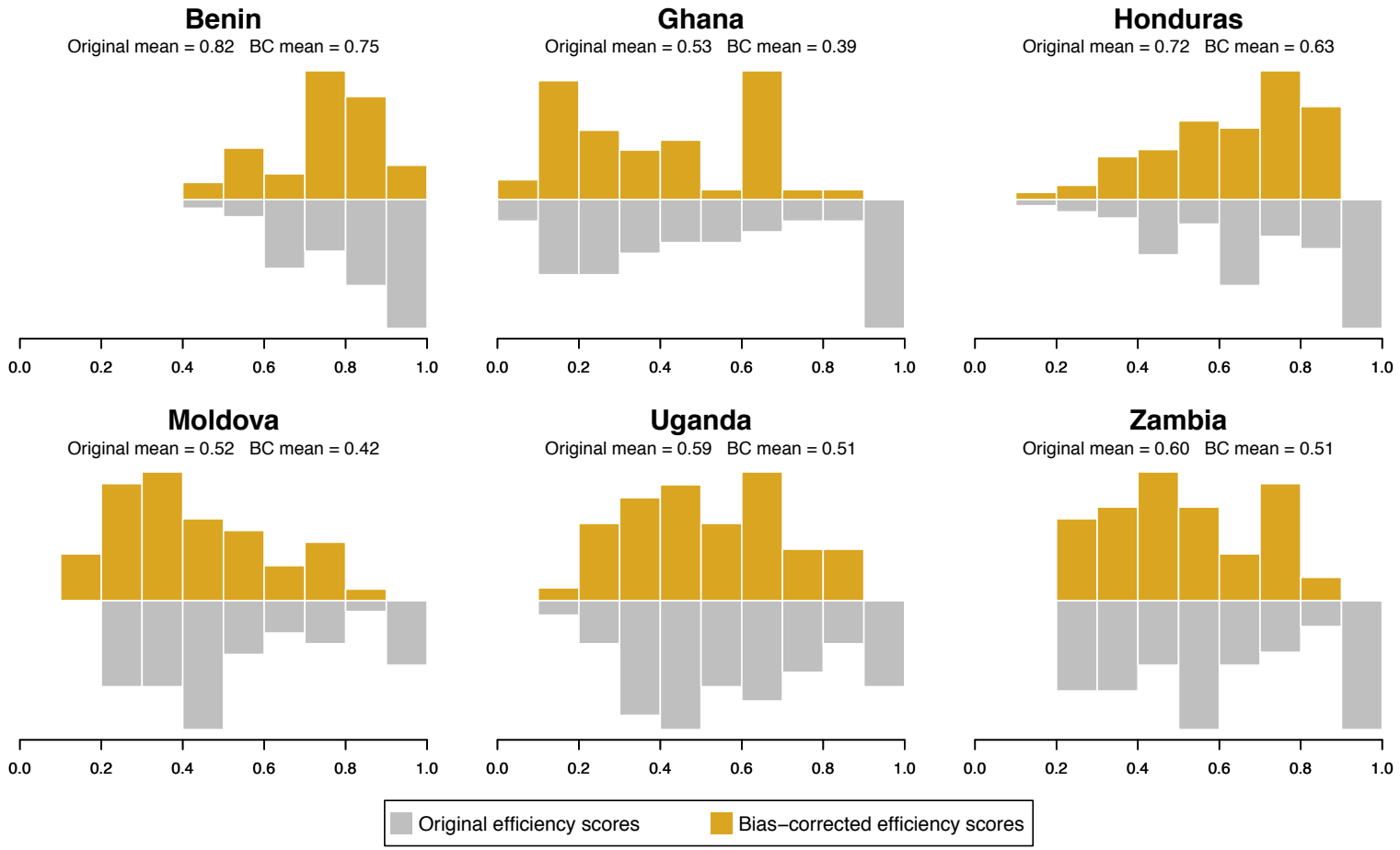
Analytic approach

- Inputs = total cost (USD)
- Outputs = DTP3 and Measles, stratified by facility vs. outreach
- Simar & Wilson approach used to obtain unbiased efficiency scores, via parametric bootstrap
- Bias-corrected efficiency scores regressed on explanatory variables to understand correlates of efficiency
- Analyses conducted for each country + pooled dataset

Distribution of inputs / outputs



Efficiency scores for individual countries



Explanatory variables: individual countries

Variable*	Benin	Ghana	Honduras	Moldova	Uganda	Zambia
Intercept	0.93 [0.10, 1.56]	-10.8 [-46.7, 6.00]	-26.8 [-69.2, -2.94]	0.28 [-1.27, 1.44]	-1.34 [-10.8, 2.03]	1.84 [-0.83, 3.94]
log(Doses)	0.07 [-0.12, 0.27]	-4.71 [-11.9, -1.06]	-3.46 [-10.2 -0.59]	-1.38 [-2.26, -0.65]	0.50 [-0.52, 1.81]	-0.15 [-0.78, 0.40]
DTP3 coverage	-0.26 [-0.49, -0.08]	3.23 [-0.40, 9.55]	0.18 [-2.70, 3.35]	-0.09 [-0.47, 0.37]	-0.14 [-1.09, 0.72]	-0.12 [-0.60, 0.30]
Govt owned	0.21 [-0.31, 0.90]	-8.17 [-21.3, 1.04]	---	---	0.76 [-0.93, 3.35]	-0.44 [-2.11, 1.41]
Urban	0.08 [-0.31, 0.47]	-7.74 [-31.8. 1.65]	4.03 [-0.39, 13.5]	0.19 [-1.85, 1.98]	0.75 [-1.09, 3.11]	-1.90 [-3.89, -0.51]
Any beds	---	18.8 [4.19, 52.4]	20.9 [2.74, 57.7]	3.33 [1.94, 4.99]	1.80 [-0.49, 6.51]	1.04 [-0.02, 2.56]
Opened post-2008	-1.06 [-5.33, -0.17]	-4.38 [-14.7, 1.81]	---	---	-1.67 [-8.73, 1.47]	-2.29 [-27.5, 2.56]
Residual std dev.	0.33 [0.21, 0.51]	4.08 [2.31 7.16]	2.22 [1.02, 3.99]	1.03 [0.76, 1.38]	1.47 [0.89, 2.83]	0.95 [0.67, 1.33]

* Truncated regression model. Intervals obtained by parametric bootstrap with 5,000 iterations.

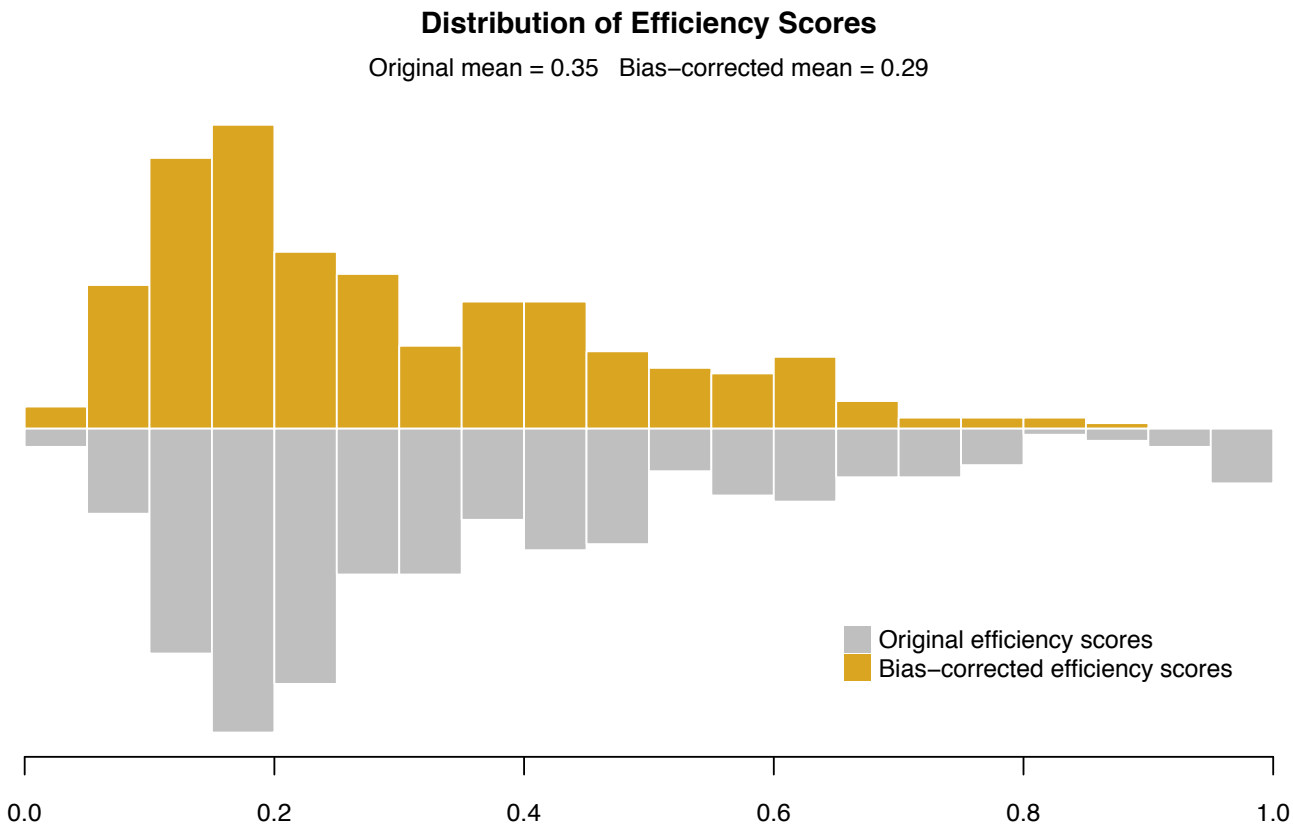
→ For 3 out of 6 countries, sites with greater service volume on average more efficient

→ For 3 out of 5 countries, sites reporting any beds on average less efficient

Pooling data across countries

- Individual countries: small sample size → noisy estimates
- Desirable to pool data for analysis, but unclear how
- Approach 1: Country-level datasets combined, with ppp conversion factor used as price index (i.e. inputs measured in int. dollars)
- Approach 2: Efficiency scores from individual countries combined for regression analysis

Approach 1: efficiency scores for pooled data

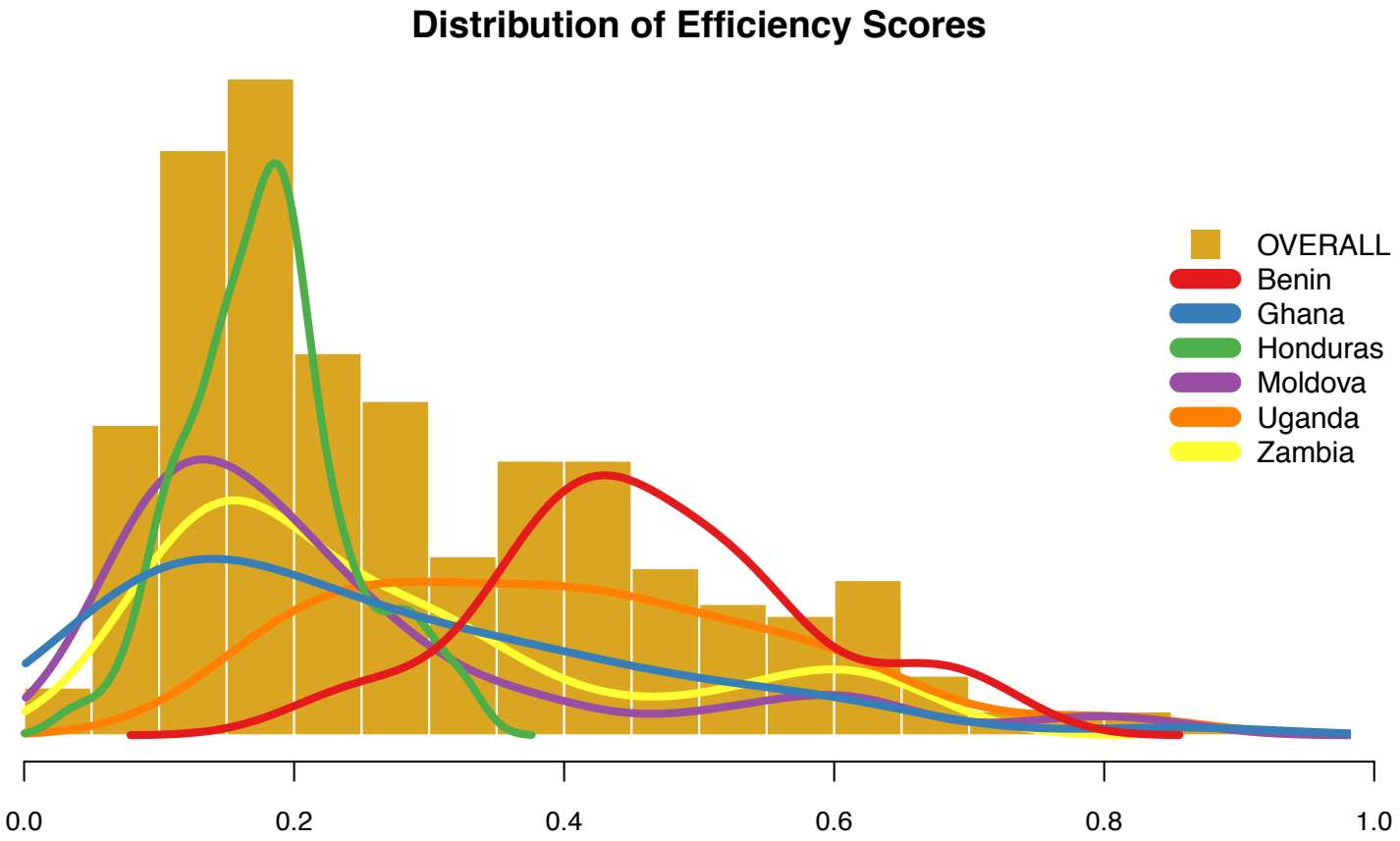


Explanatory variables: pooled analysis I

Variable	Coefficient [95% interval]*
Intercept	-11.6 [-25.5, -0.8]
log(Doses)	-1.2 [-2.1, -0.3]
DTP3 coverage	-3.7 [-7.8, -0.2]
Govt owned	-1.3 [-5.8, 3.8]
Urban	-0.7 [-3.2, 1.8]
Any beds	11.5 [7.3, 17.2]
Opened post-2008	0.4 [-4.0, 4.40]
Ghana indicator	19.0 [12.2, 28.9]
Honduras indicator	18.7 [12.0, 28.5]
Moldova indicator	18.6 [11.3, 28.8]
Uganda indicator	6.7 [0.1, 15.3]
Zambia indicator	17.8 [11.0, 27.5]
Residual std dev.	4.9 [4.1, 5.9]

* Efficiency scores estimated from pooled country data, PPP conversion factor as price index

Approach 1: reasonable to pool with simple price index?



Explanatory variables: pooled analysis II

Variable	Coefficient [95% interval]*	Coefficient [95% interval]**
Intercept	-11.6 [-25.5, -0.8]	-17.6 [-55.1, 0.2]
log(Doses)	-1.2 [-2.1, -0.3]	-2.7 [-5.9, -1.0]
DTP3 coverage	-3.7 [-7.8, -0.2]	-2.2 [-2.1, 7.5]
Govt owned	-1.3 [-5.8, 3.8]	-3.3 [-8.9, 1.2]
Urban	-0.7 [-3.2, 1.8]	-0.3 [-4.4, 3.3]
Any beds	11.5 [7.3, 17.2]	10.0 [4.4, 21.6]
Opened post-2008	0.4 [-4.0, 4.40]	-4.2 [-10.7, -0.1]
Ghana indicator	19.0 [12.2, 28.9]	31.9 [14.4, 72.8]
Honduras indicator	18.7 [12.0, 28.5]	25.9 [10.4, 61.5]
Moldova indicator	18.6 [11.3, 28.8]	23.0 [8.3, 56.9]
Uganda indicator	6.7 [0.1, 15.3]	25.0 [9.9, 60.8]
Zambia indicator	17.8 [11.0, 27.5]	25.1 [9.9, 60.6]
Residual std dev.	4.9 [4.1, 5.9]	3.5 [2.4, 5.5]

* Efficiency scores estimated from pooled country data, PPP conversion factor as price index

** Efficiency scores from individual country analyses, results merged for pooled regression

Conclusions

- Country-level average efficiency ranged from 39% to 75%
- Across multiple regression specifications, sites with higher overall service volume and sites reporting no beds appear systematically more efficient
- Benin appears an outlier – more efficient? Alternately more homogeneous delivery sites

Next steps

- As with previous presentation: revise/extend analyses when final dataset available
- Stratification of inputs into major categories (capital, labor, vax consumables)
- Refine approach for cross-country analysis

Thank you

Questions?