Explaining the variation in on-site AIDS treatment costs

Econometric results and policy implications the MATCH study of 161 facilities from five countries:

(Multi-country Analysis of Treatment Cost for HIV)

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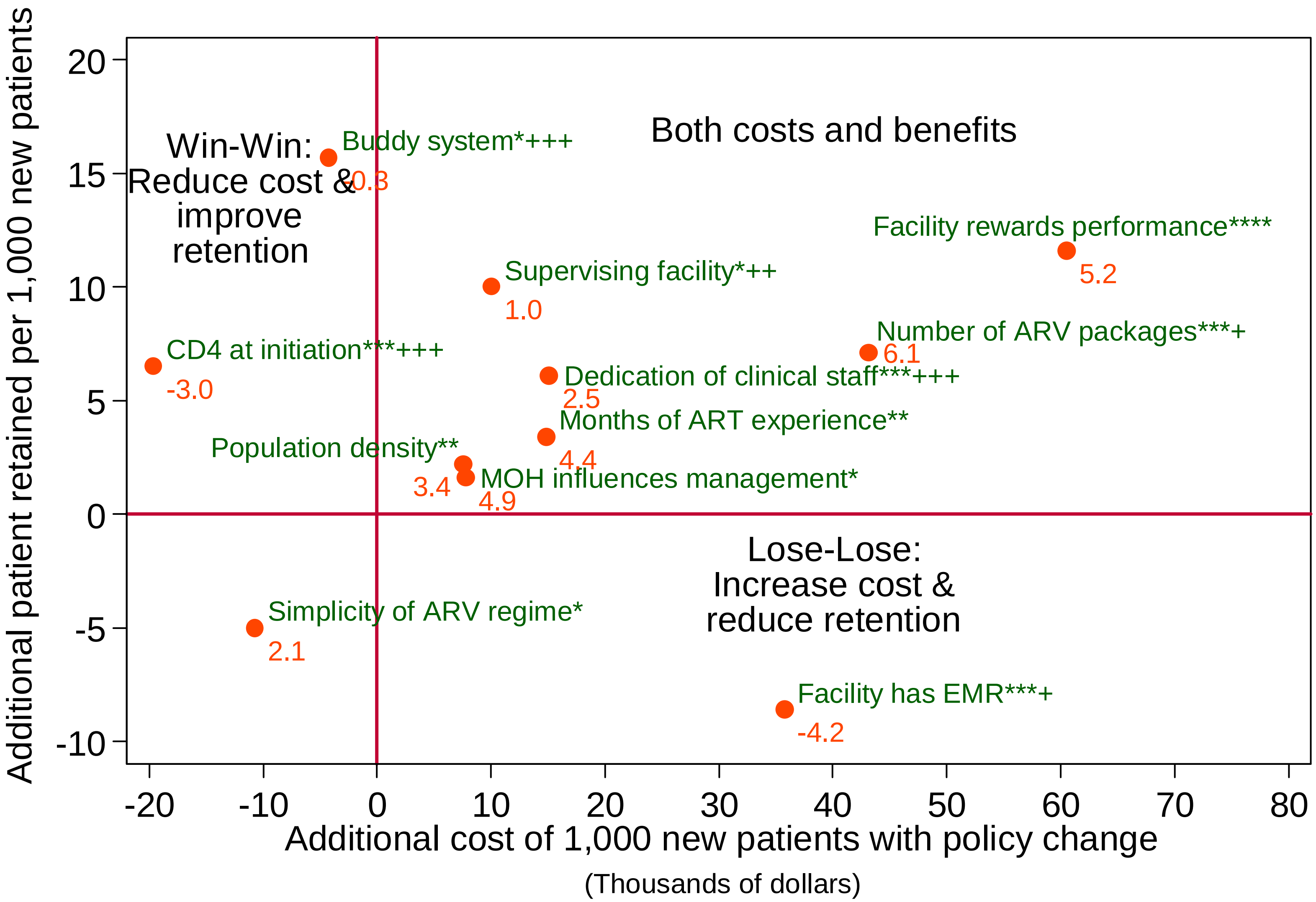
International AIDS Economics Network
Washington, DC

Study partners

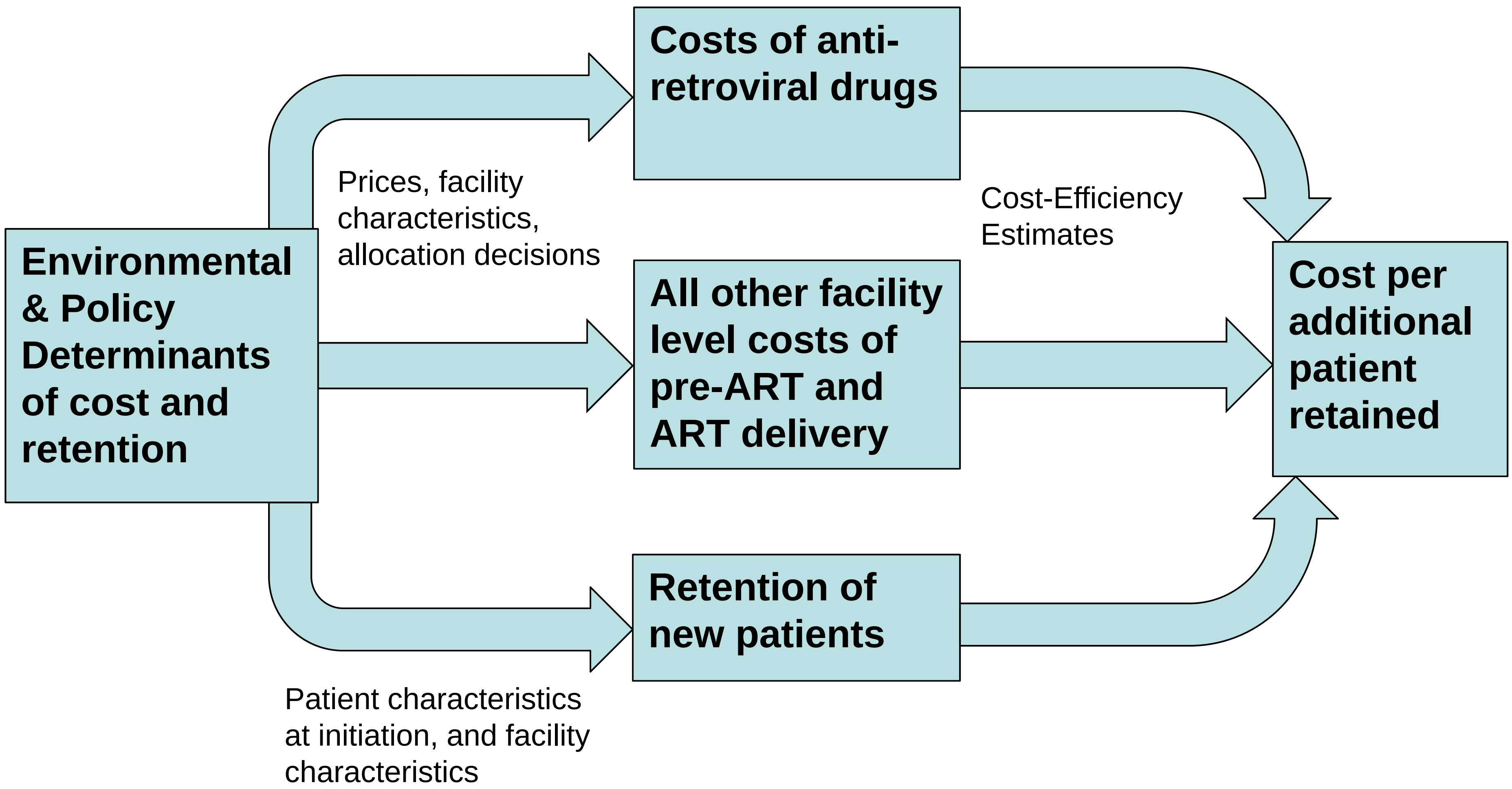
- Ministries of health in Rwanda, Ethiopia, Malawi, Zambia and South Africa
- The managers of 161 health facilities
- Clinton Health Access Initiative
- Gates Foundation
- Center for Global Development

Cost and benefits of determinants affecting both cost-efficiency and retention



Statistical significance in cost-efficiency regression: * p<0.20; ** p<0.10; *** p<0.05
Statistical significance in retention regression: + p<0.20; ++ p<0.10; +++ p<0.05

Plan of the analysis



Methods (1)

- Non-ARV costs
  - Translog cost function of outputs (2) and prices (5) on pooled data for 4 countries

$$\ln(NonARVCost_i) = \alpha_o + \sum_{m=1}^{2} \beta_m \ln(y_{mn}) + \frac{1}{2}\beta_{12}\ln(y_{1i})\ln(y_{2i})$$

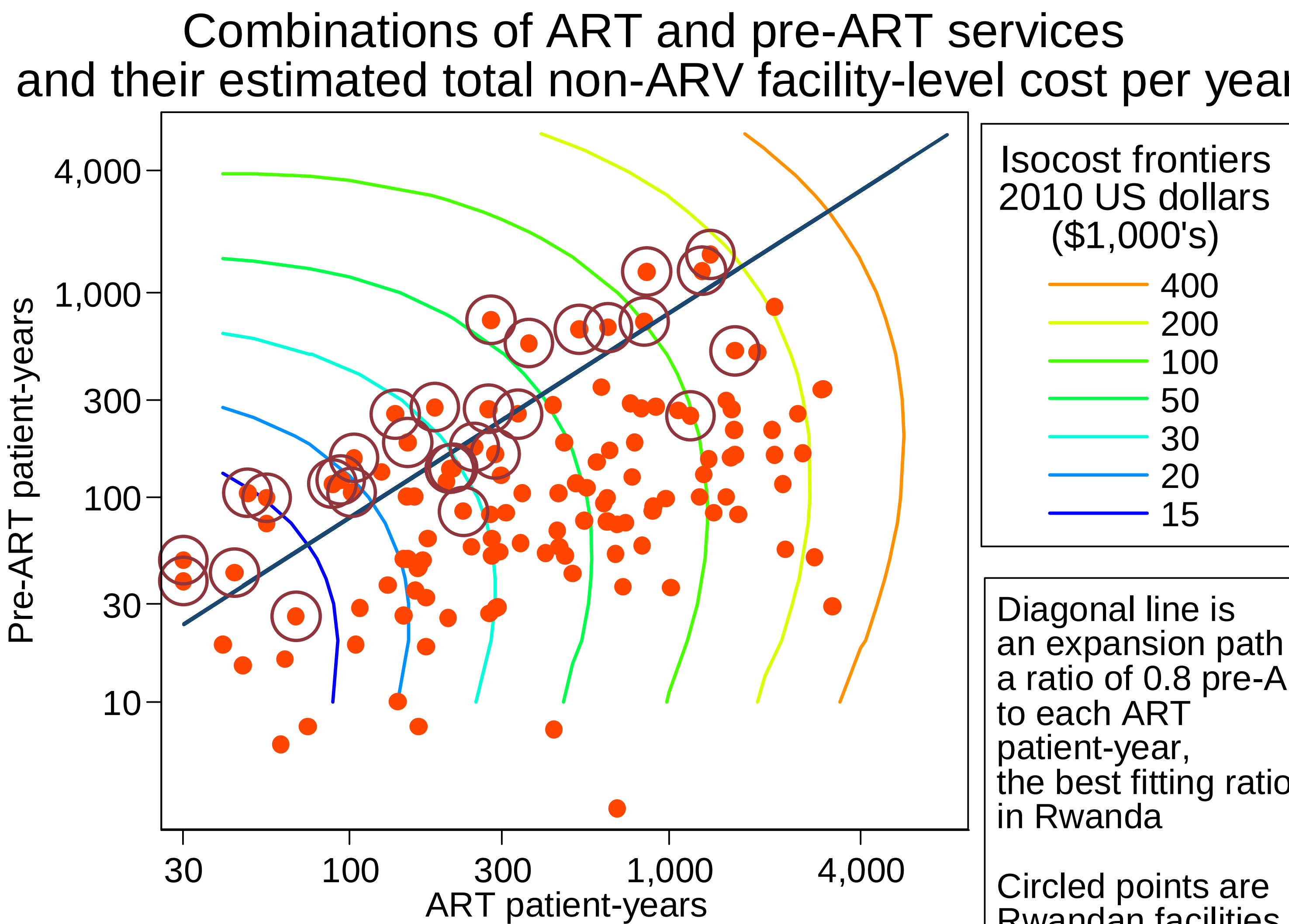
$$+\sum_{k=1}^{5}\gamma_k \ln(P_{ki}) + \frac{1}{2}\sum_{k=1}^{5}\sum_{j=1}^{5}\gamma_{kj}\ln(P_{ki})\ln(P_{ji}) + \sum_{k=1}^{5}\sum_{m=1}^{2}\delta_{km}\ln(y_{mi})\ln(P_{ki}) + \varepsilon_i$$

    - Estimate jointly with the 5 share equations: S_1-S_5

$$S_k = \gamma_k + \sum_{j=1}^{5}\gamma_{kj}\ln(P_{ji}) + \sum_{m=1}^{2}\delta_{km}\ln(y_{mi})\ln(P_{ki}) + \varepsilon_{ki} \qquad \forall k = 1,\cdots 5$$

    - Define the residuals as the cost-inefficiency in the individual facility's delivery of pre-ART and ART services
  - Use stepwise regression to mine the data for statistically significant predictors of cost-efficiency
    - Allows the meaning of the determinant variables to be specific to each country

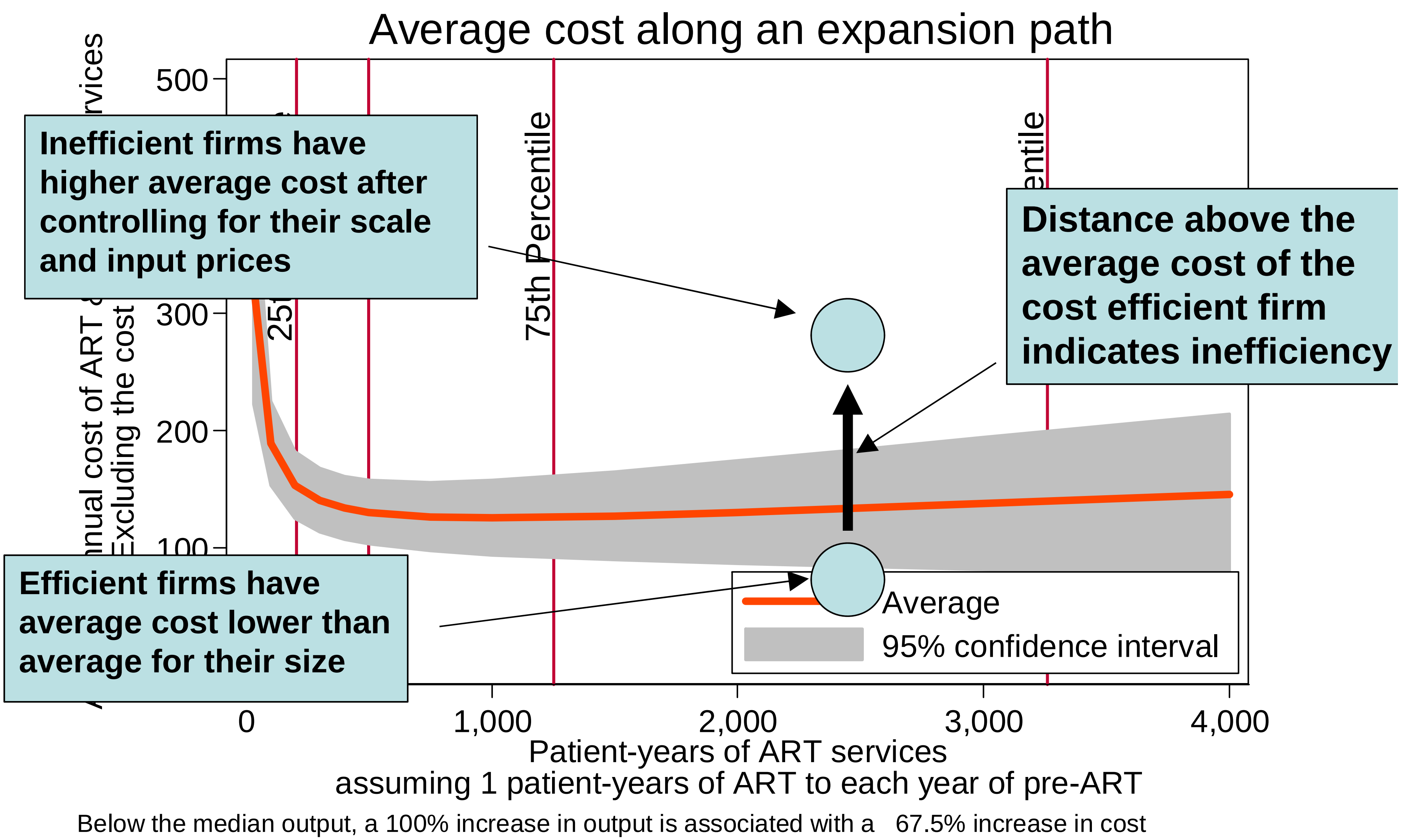
A fitted translog joint cost function reveals substantial complementarity in the production process



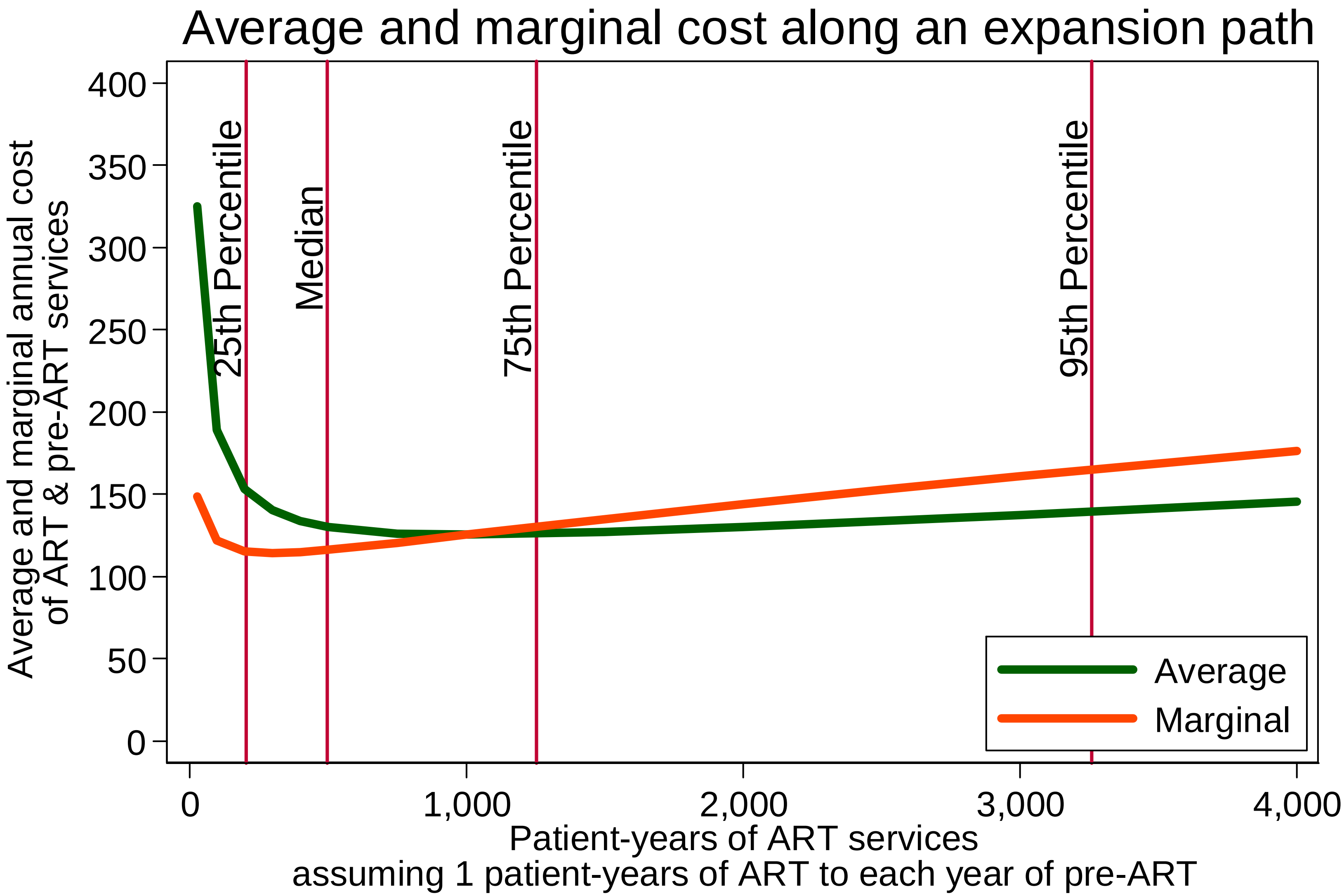
Diagonal line is an expansion path at a ratio of 0.8 pre-ART to each ART patient-year, the best fitting ratio in Rwanda

Circled points are Rwandan facilities

Average total non-ARV cost declines with the number of ART person-years served



The marginal cost of an additional patient is greater in larger facilities

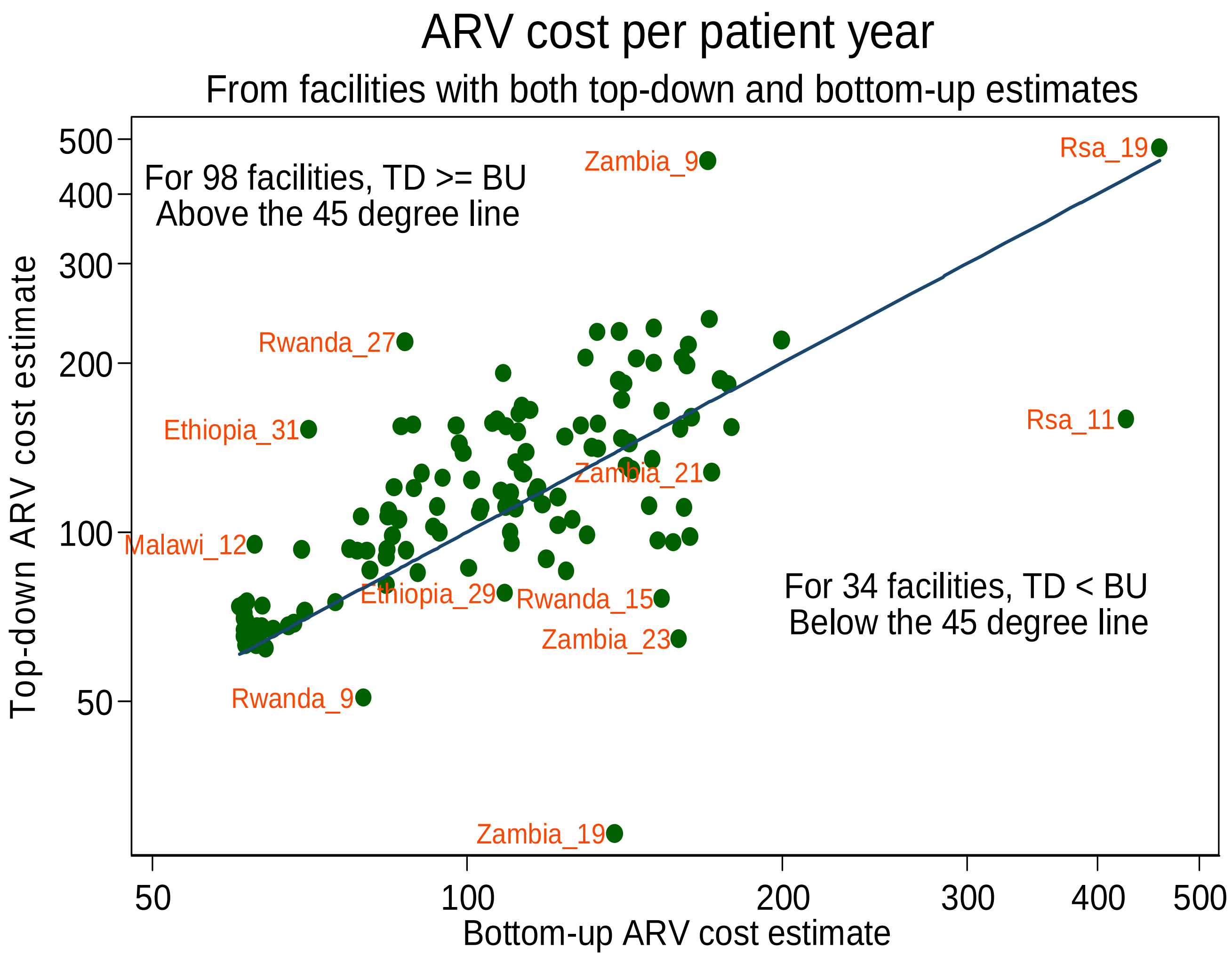


Below the median output, a 100% increase in output is associated with a 67.5% increase in cost

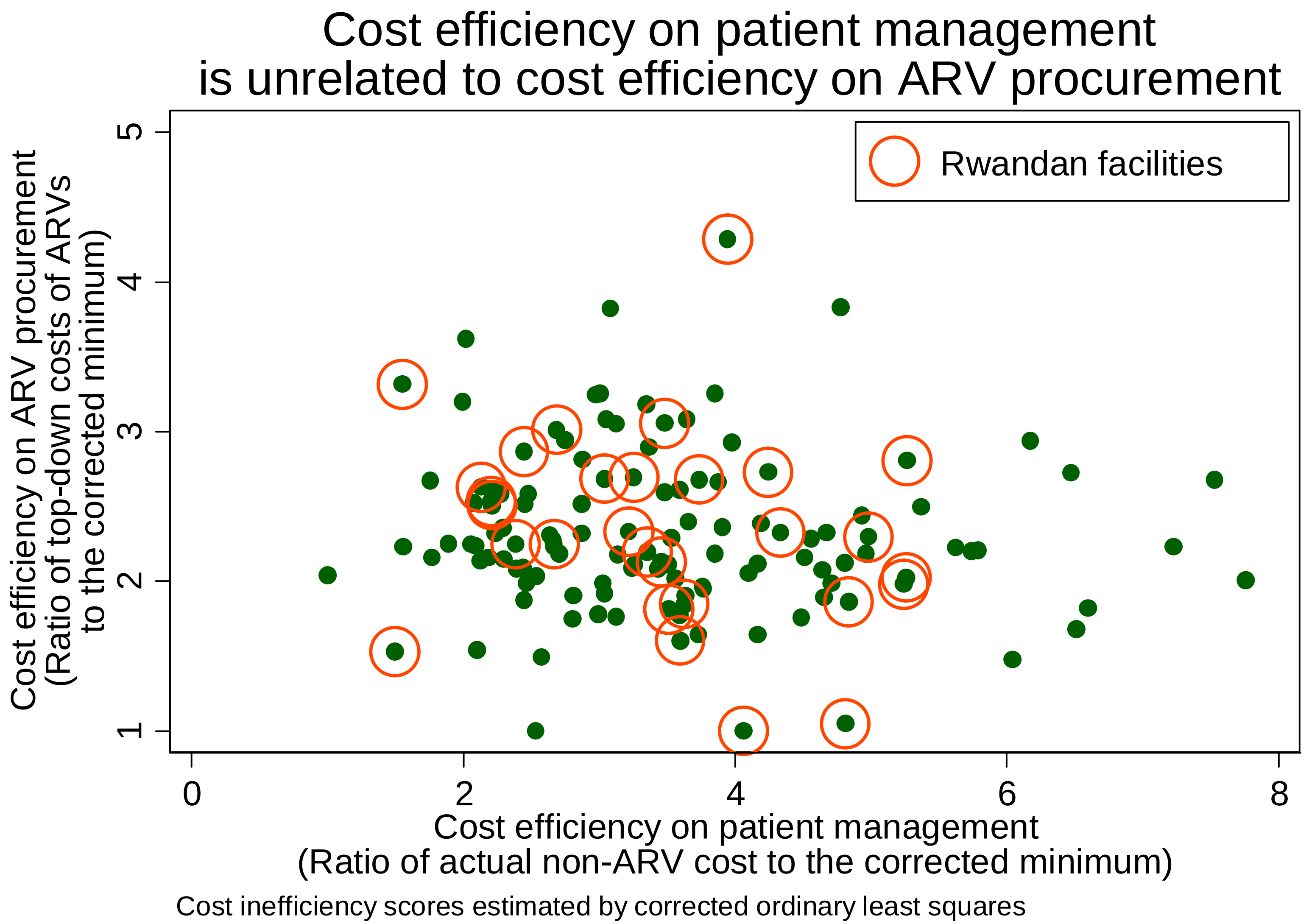
Methods (2)

- ARV costs
  - Log of Rx cost a function of a normative estimate of ARV cost plus indicators of data quality
    - Define the residuals as the cost-inefficiency in the individual facility's ARV procurement process
  - Use stepwise regression to mine the data for statistically significant predictors of cost-efficiency
    - Allows the meaning of the determinant variables to be specific to each country

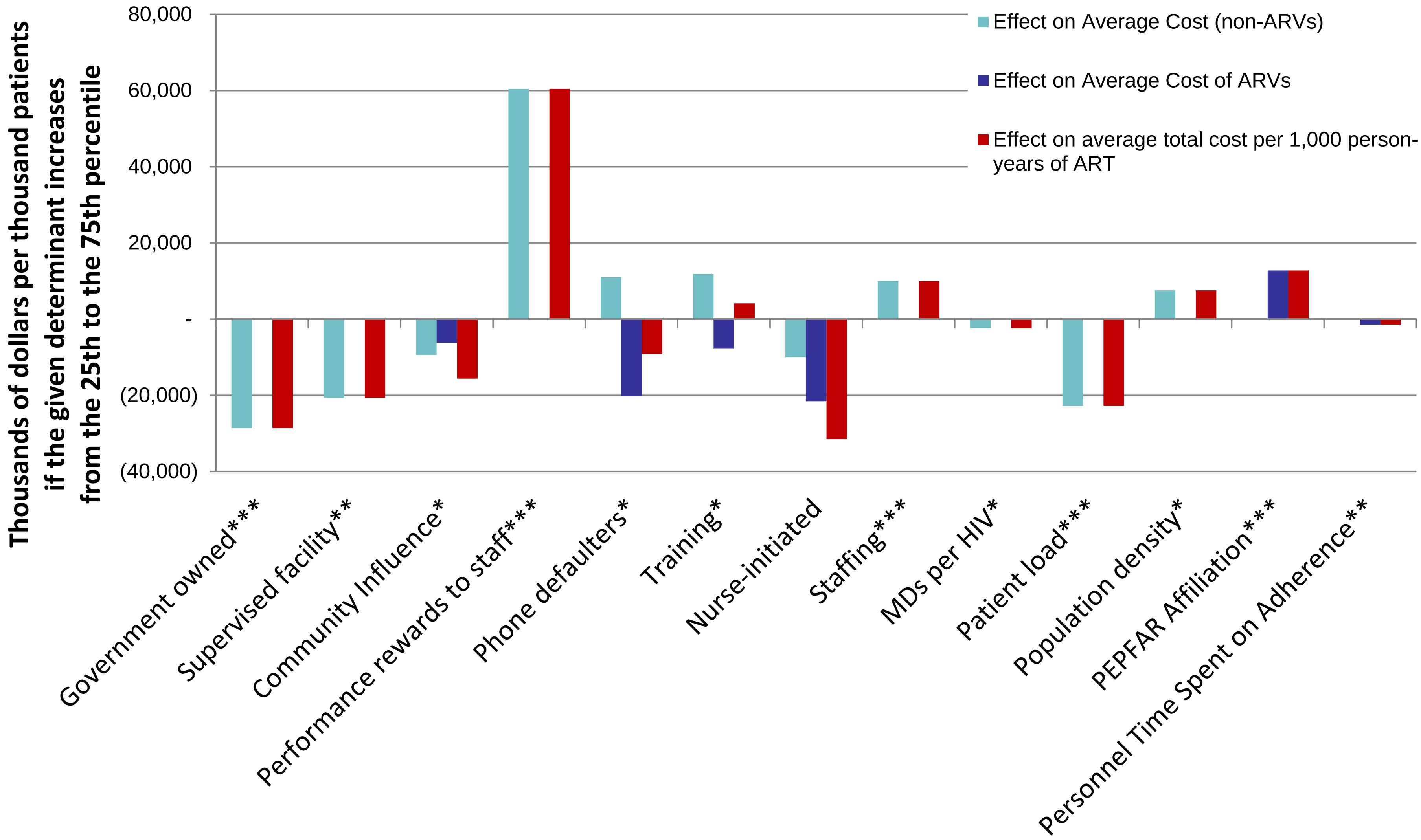
Estimates of average ARV cost per year generally exceed the normative cost estimate



Comparing the inefficiency scores on the ARV and non-ARV components of total facility-level cost



Determinants of cost-efficiency



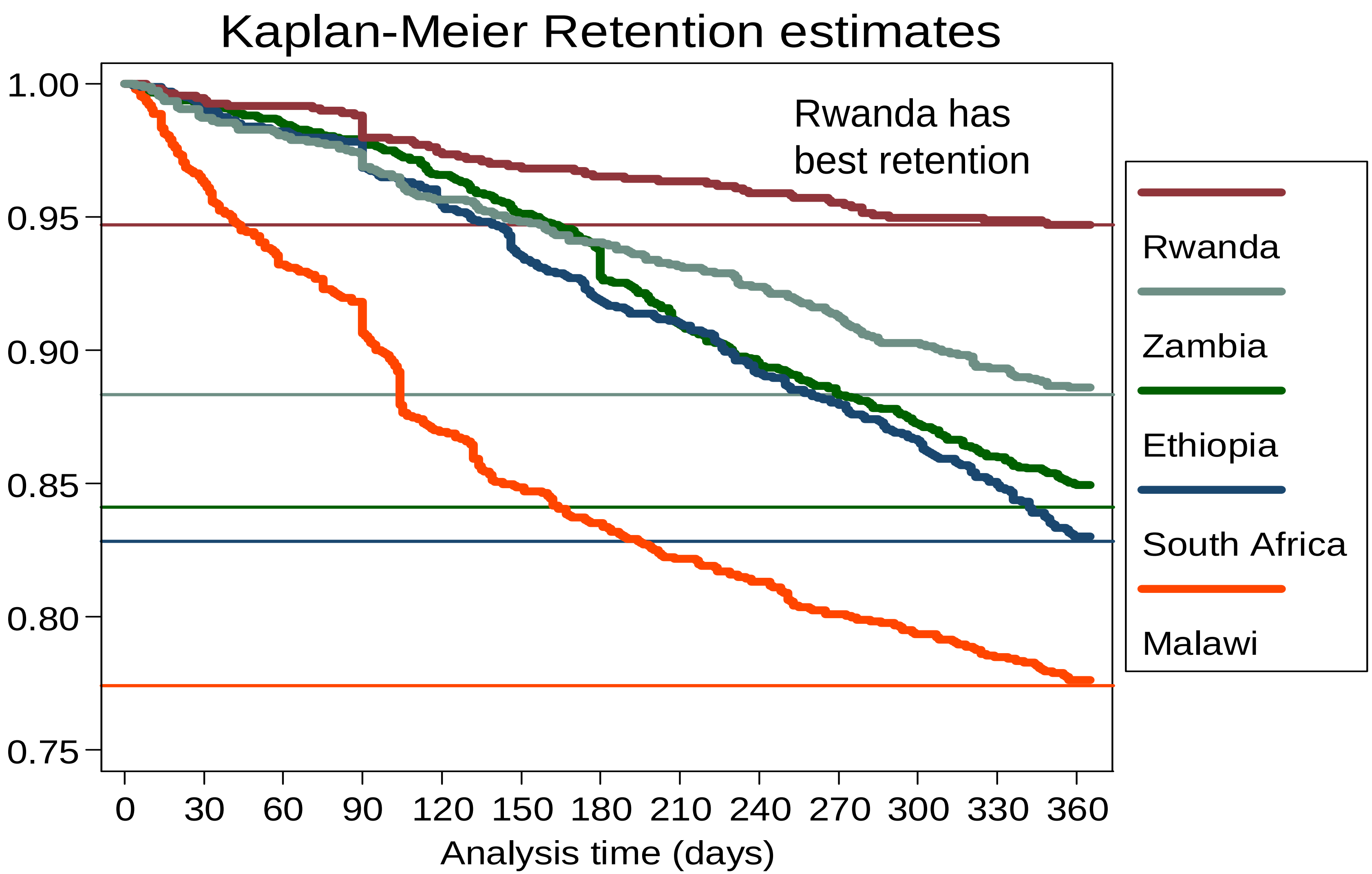
Note: Statistical significance: *p<0.20; **p<0.10; ***p<0.05

Methods (3)

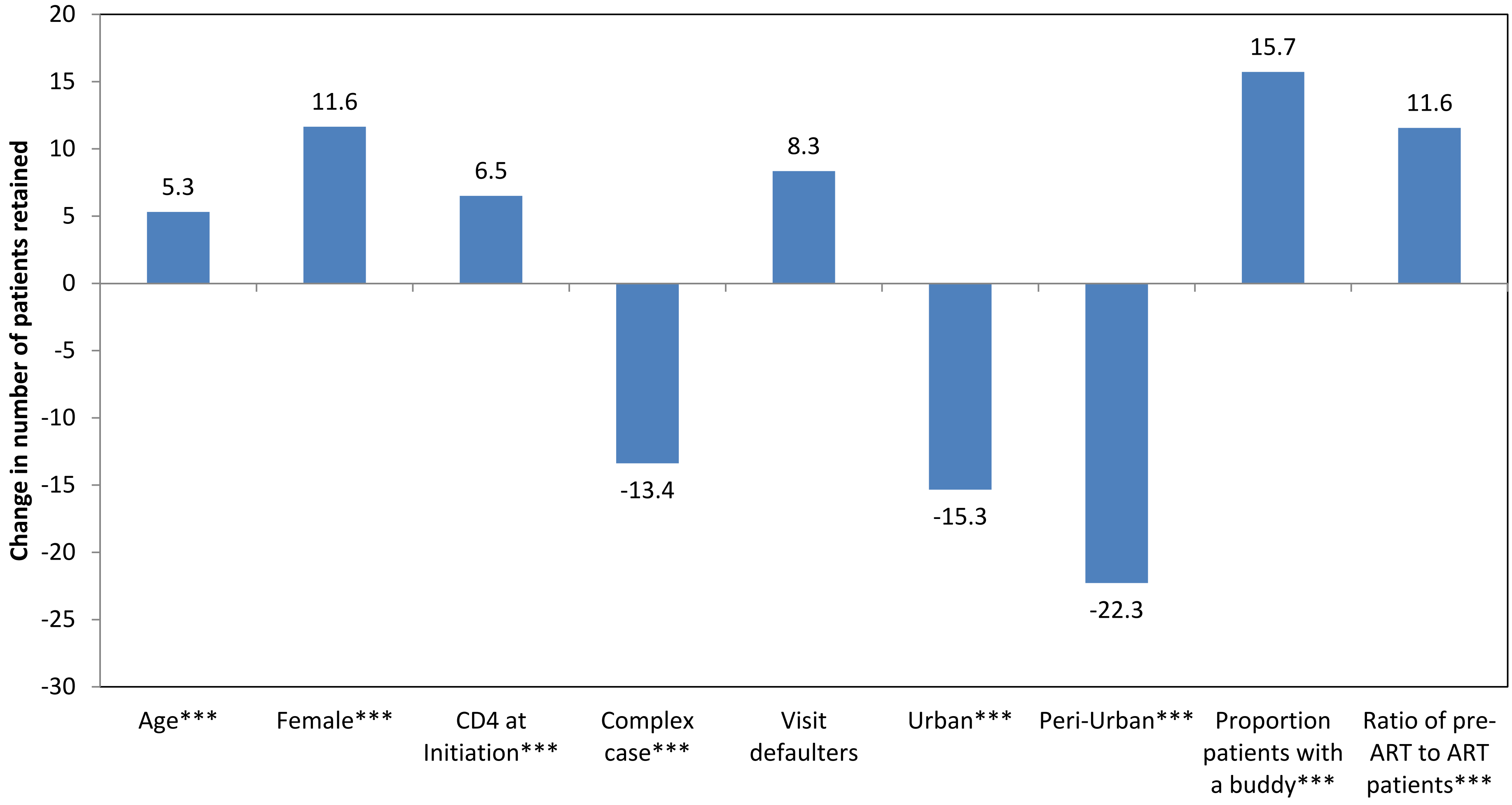
- Retention benefits
  - Estimate a Cox survival function to predict retention of new patients
  - Pooled regression on about 5,000 new patients in about 130 facilities uses
    - Individual characteristics
    - Facility characteristics
  - Use stepwise regression to mine the data for the most statistically significant determinants

Unadjusted retention by country

7,727 patients in 160 facilities



Determinants of retention



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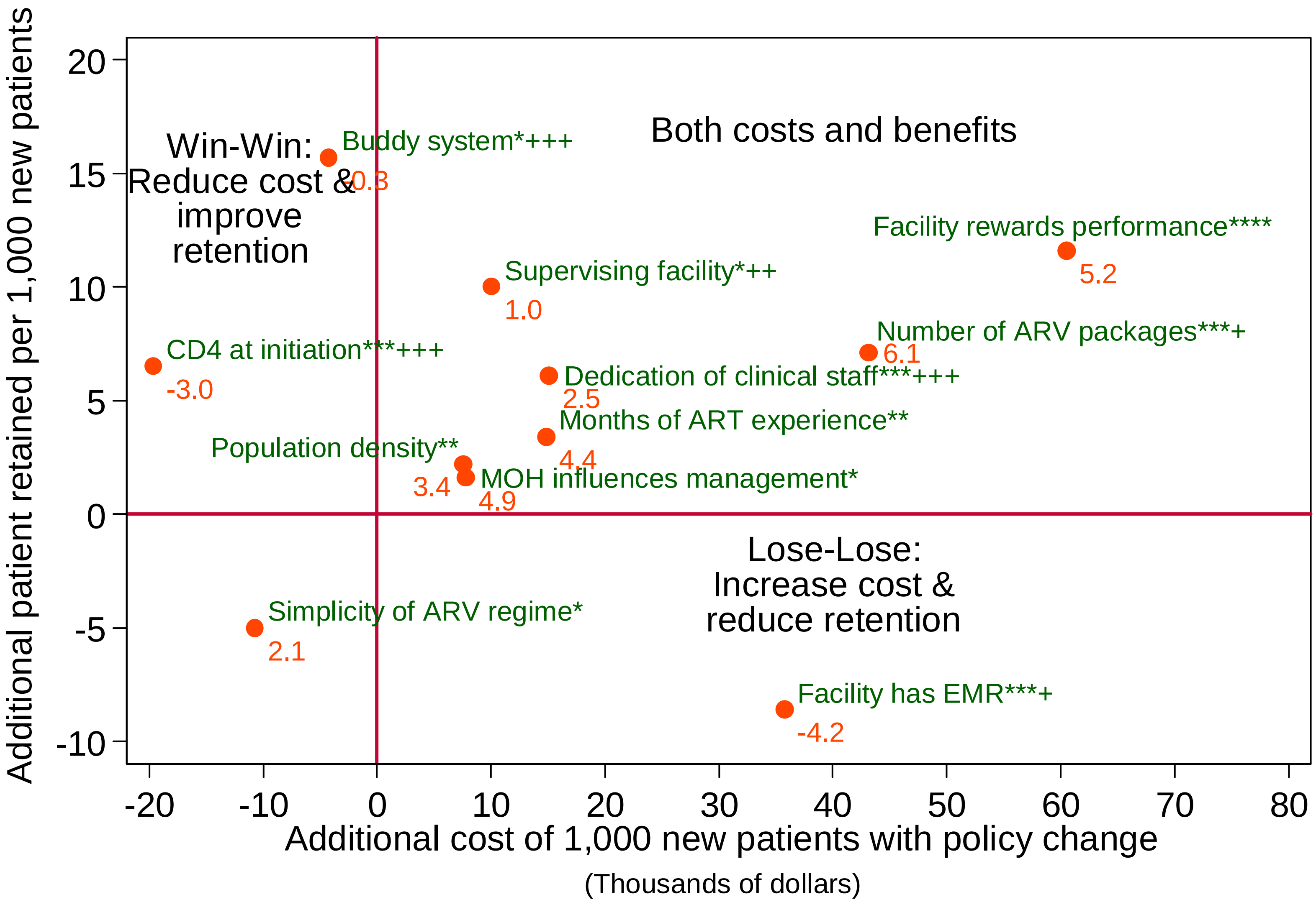
Cost and benefits of determinants affecting both cost-efficiency and retention



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Discussion

Concluding comments (1)

- Cost function
  - Application of “corrected OLS” using the translog joint cost function yields plausible estimates of average and marginal costs and provides estimates of (in)efficiency which can be analyzed in a second stage.
  - Apparent independence of the cost efficiency of ARV procurement and of other costs of delivering pre-ART and ART services justifies analyzing them separately
  - For non-drug costs, there are important complementarities between the delivery of pre-ART and ART services. Only Rwanda seems to be taking advantage of these complementarities.

Concluding comments (2)

- Retention analysis
  - Individual characteristics explain most of the variation in observed retention of new patients
  - However, some facility characteristics also contribute to explaining retention are important are most Technical efficiency
- Determinants that affect both benefits and costs
  - Early recruitment of patients a higher CD4 counts both reduces cost and increases retention and thus, for an individual facility, is a Win:Win proposition
  - A higher ratio of pre-ART to ART patients improves retention at relatively low cost
  - Several other policies are estimated to improve retention at a cost of between $1,000 to $6,000 per additional patient retained.
- Benefits of these policies may also help existing patients, so need to add those analyses

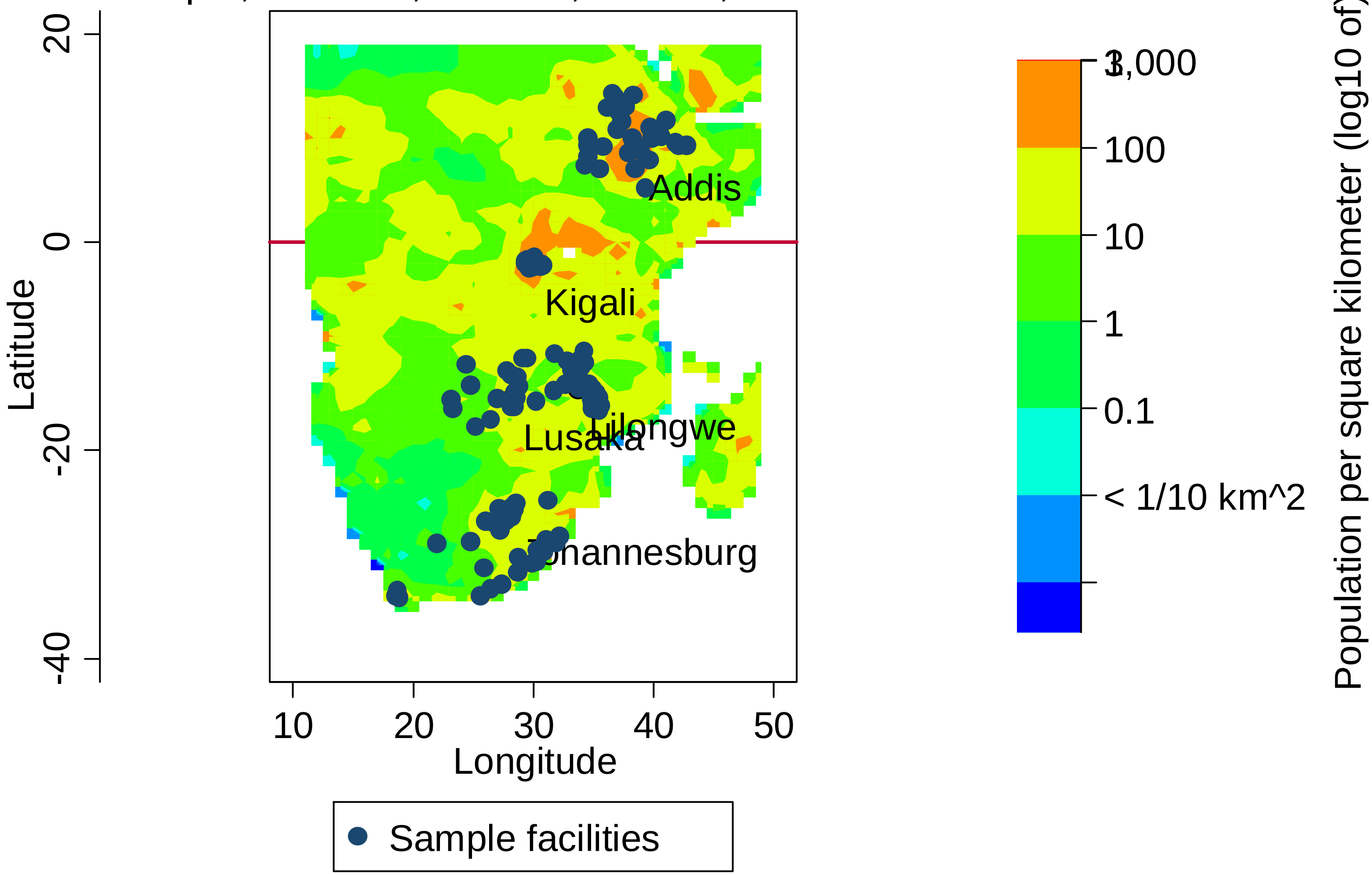
Concluding comments (3)

- Next steps:
  - Extend the analysis of non-ARV cost to the South African sample of facilities
  - Provide individualized analysis for each of the five countries
  - Scale up cost estimates to estimate the total cost of ART in all of the five countries
  - Projecting future costs of ART treatment under alternative scenarios regarding the mix of facilities to be scaled up and the implementation of supervision and managerial incentives

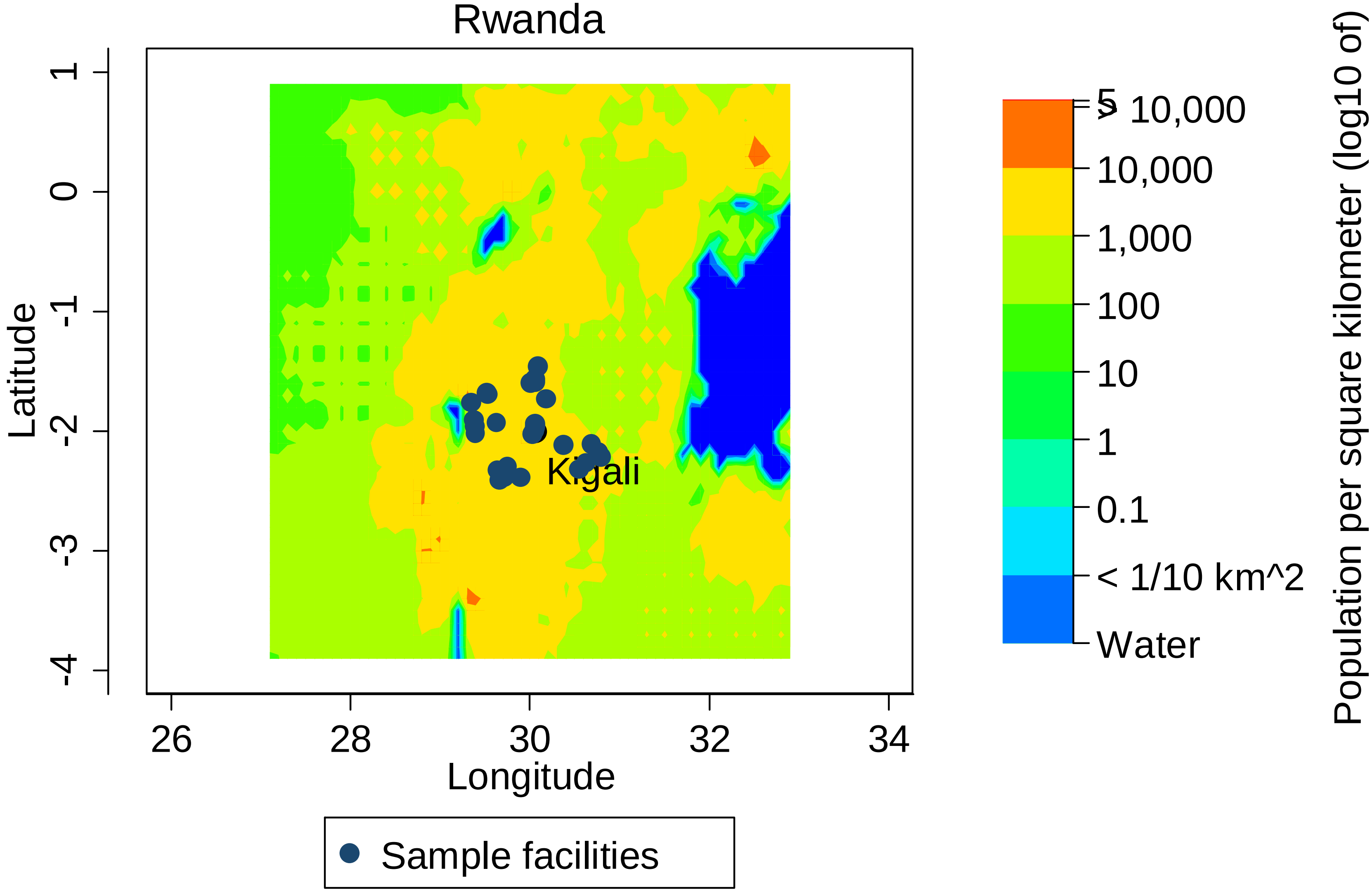
END

Location of sampled ART facilities

Ethiopia, Rwanda, Zambia, Malawi, South Africa



Location of sampled ART facilities



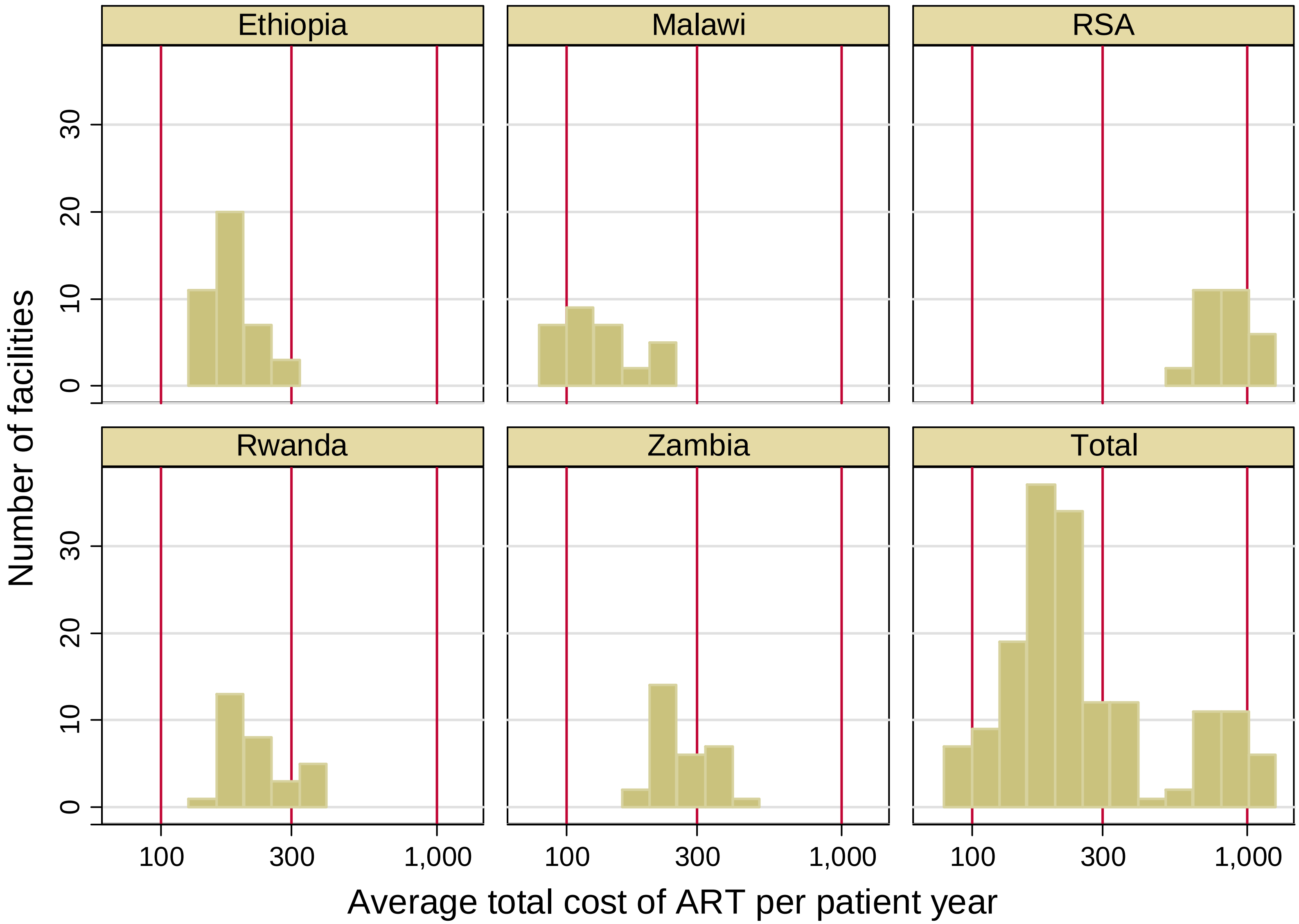
Granularity: Squares of 0.1 x 0.1 degree

Outline of the talk

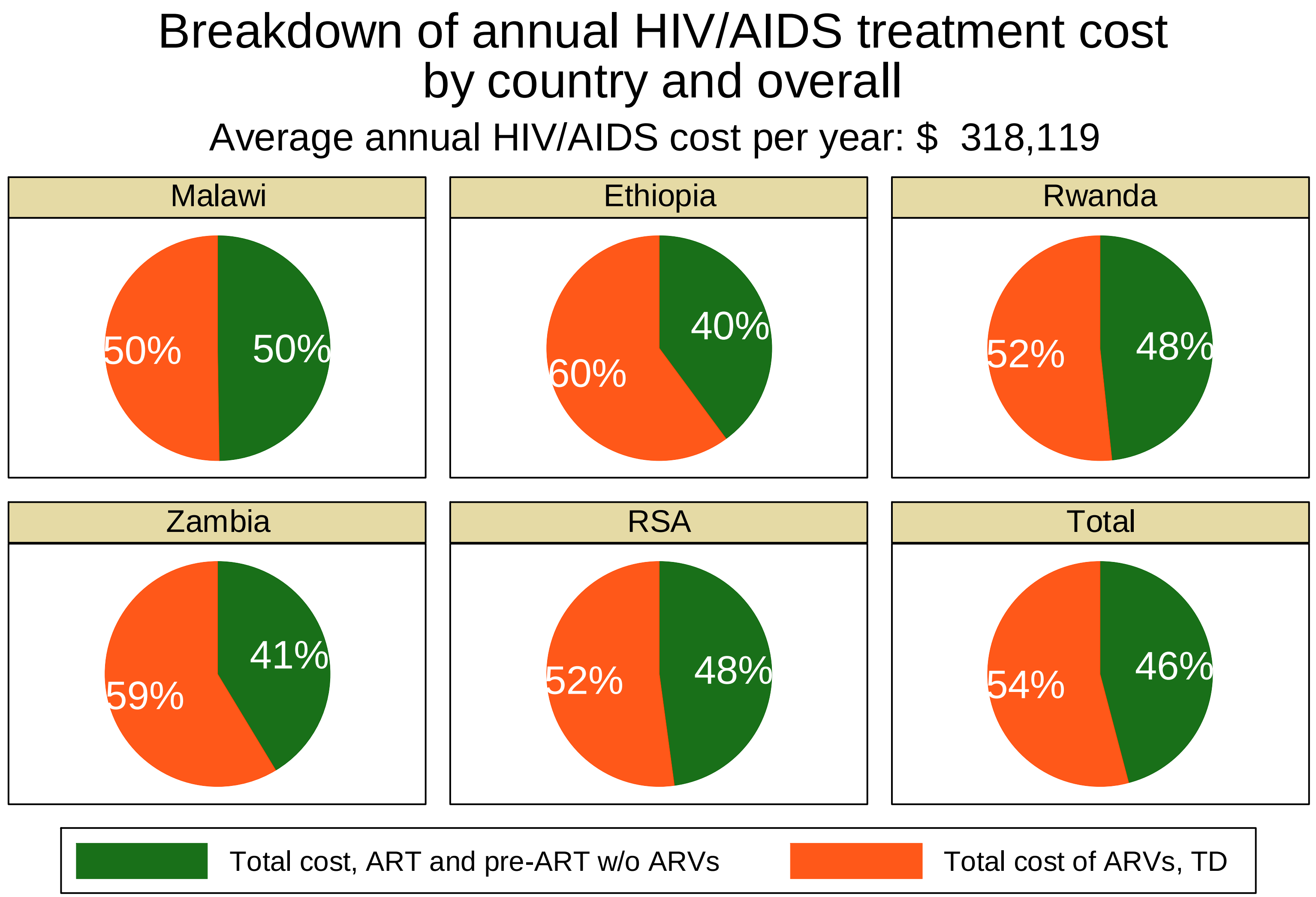
- Heterogeneity in on-site cost of ART by component
  - Study data from 5 countries (2010)
- Explaining patient retention
- Explaining the variation in each cost component
- Clues to efficiency in the ratio of bottom-up to top-down ARV costing
- Discussion

HETEROGENEITY
IN ON-SITE COST OF ART
BY COMPONENT

Variation in average cost of ART



Analyze ARV cost separately from all other costs of ART and pre-ART

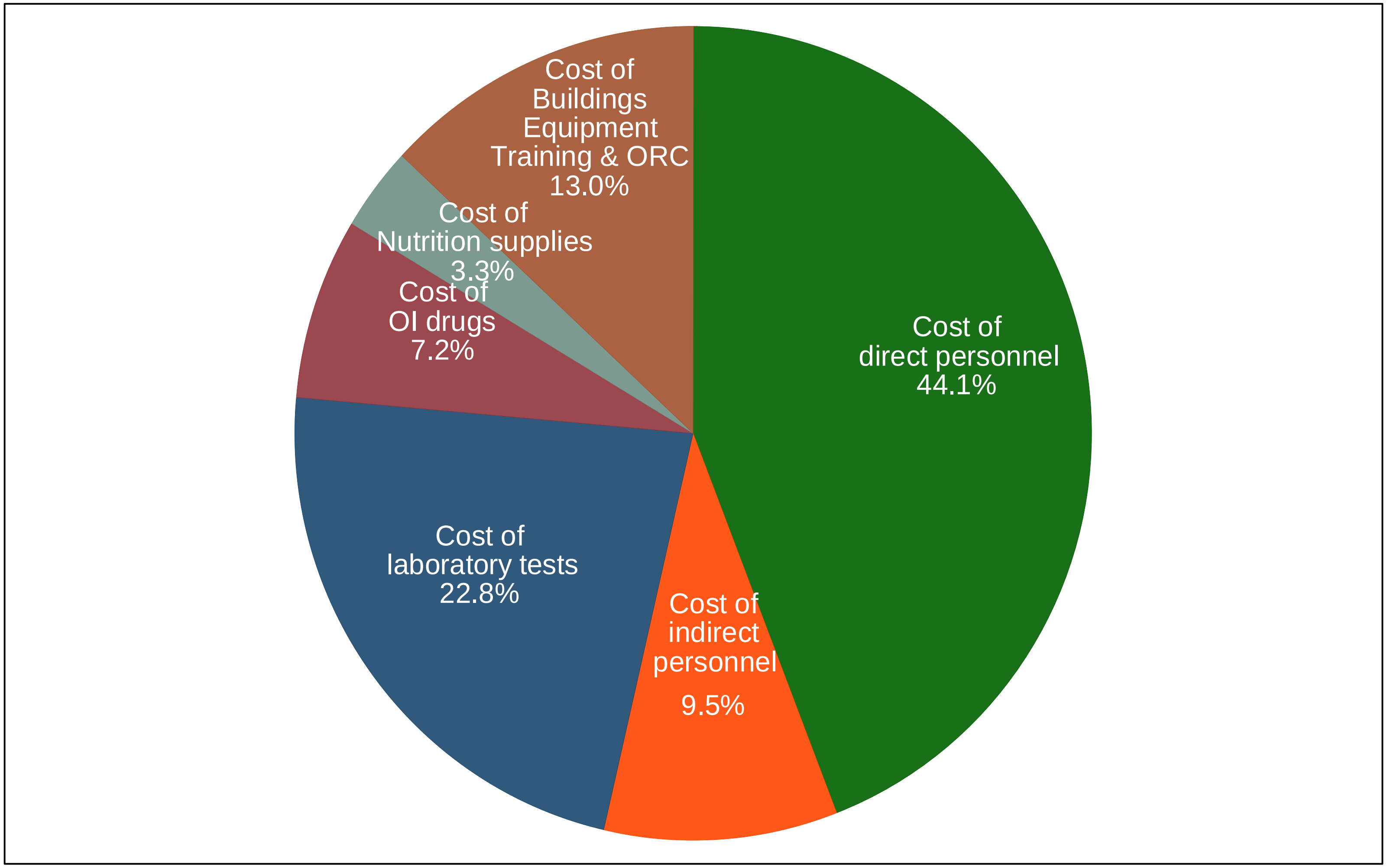


For the 144 facilities with top-down estimates of ARV cost

Operational costs can be separated into 6 components

Breakdown of annual non-ARV costs in the five-country sample

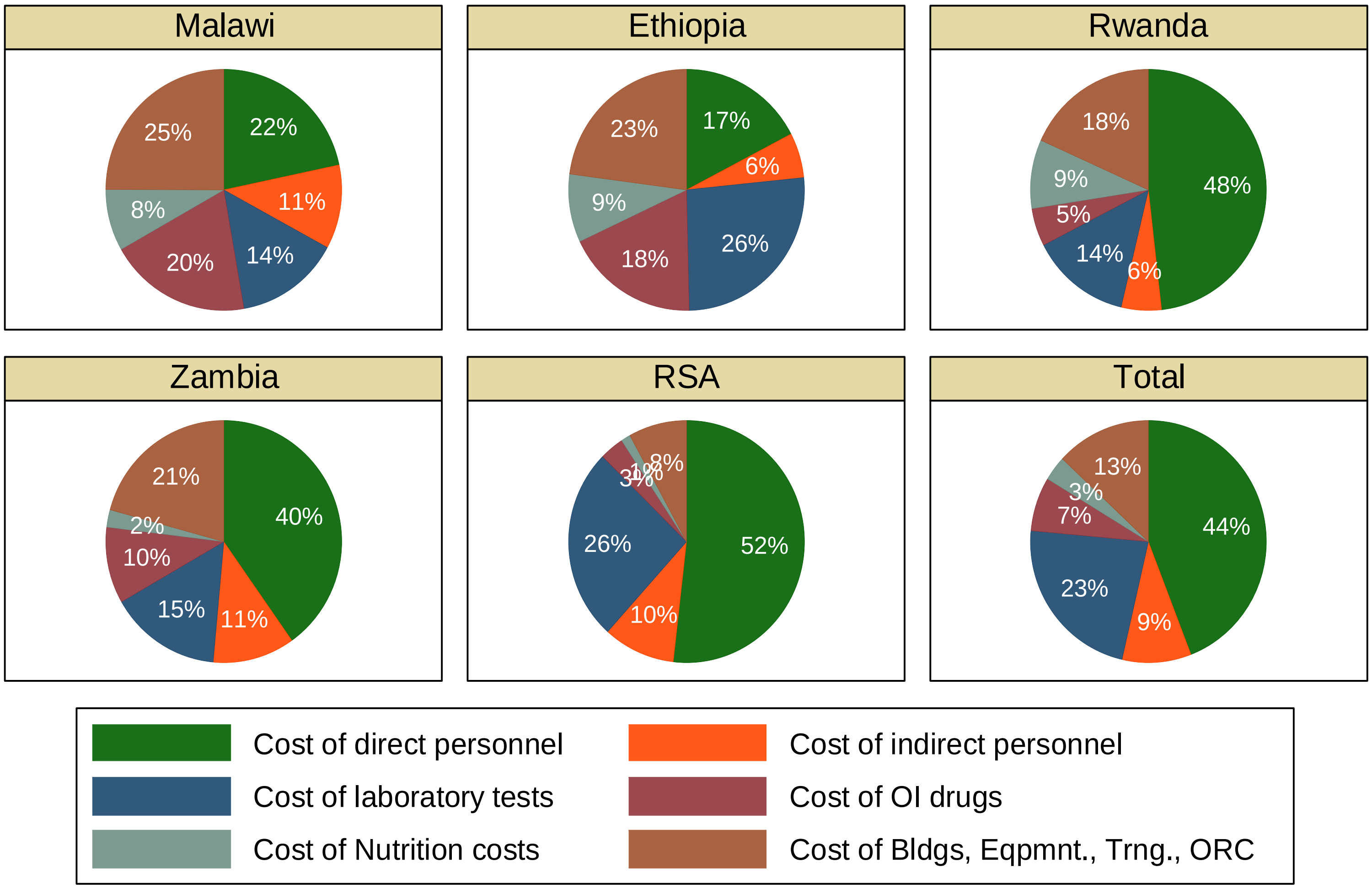
Average non-ARV cost per year: $ 184,816



For the 161 facilities sampled in the five-countries

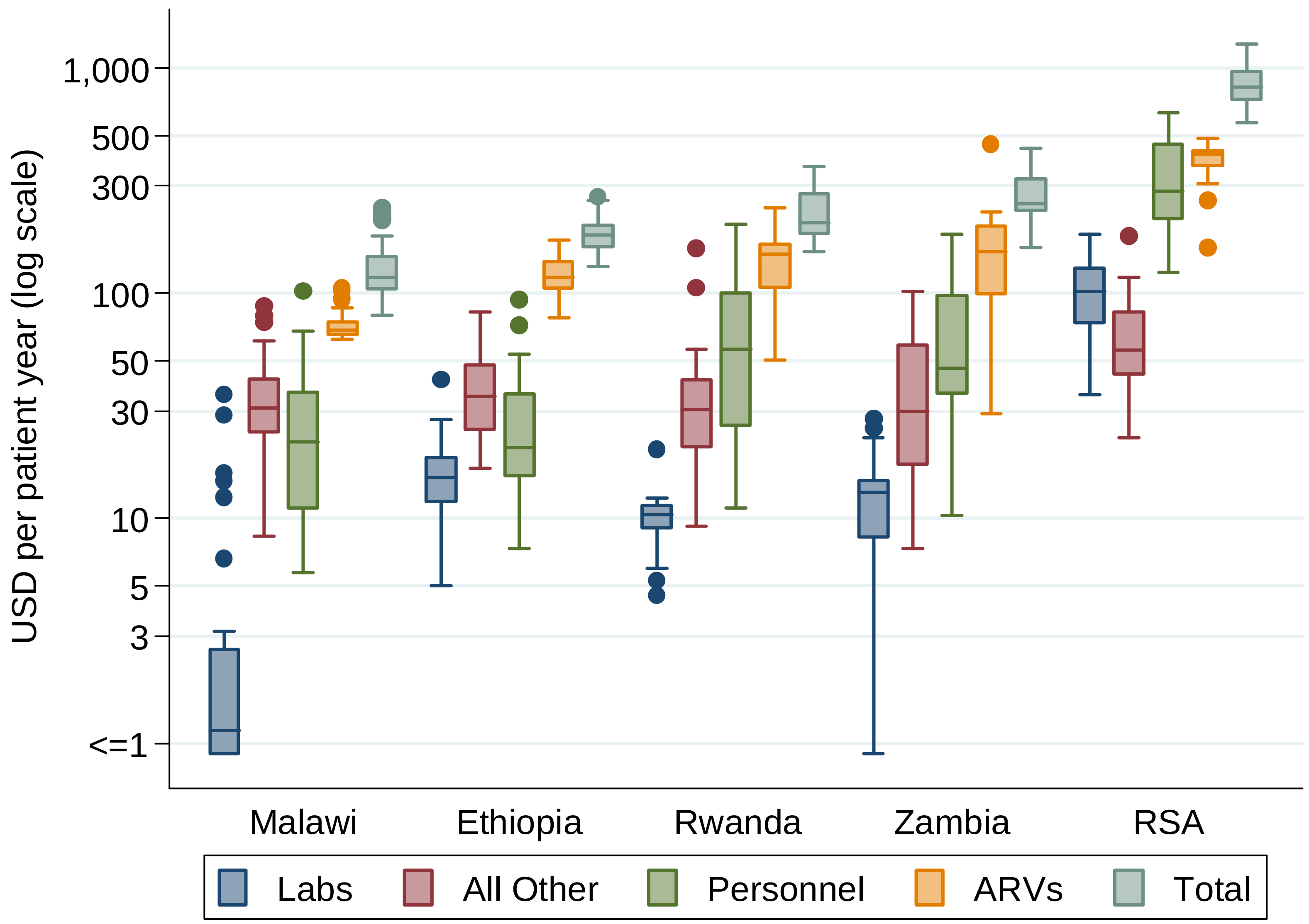
Direct and indirect personnel cost are from 23% to 62% of non-ARV costs

Breakdown of annual non-ARV costs by country and overall

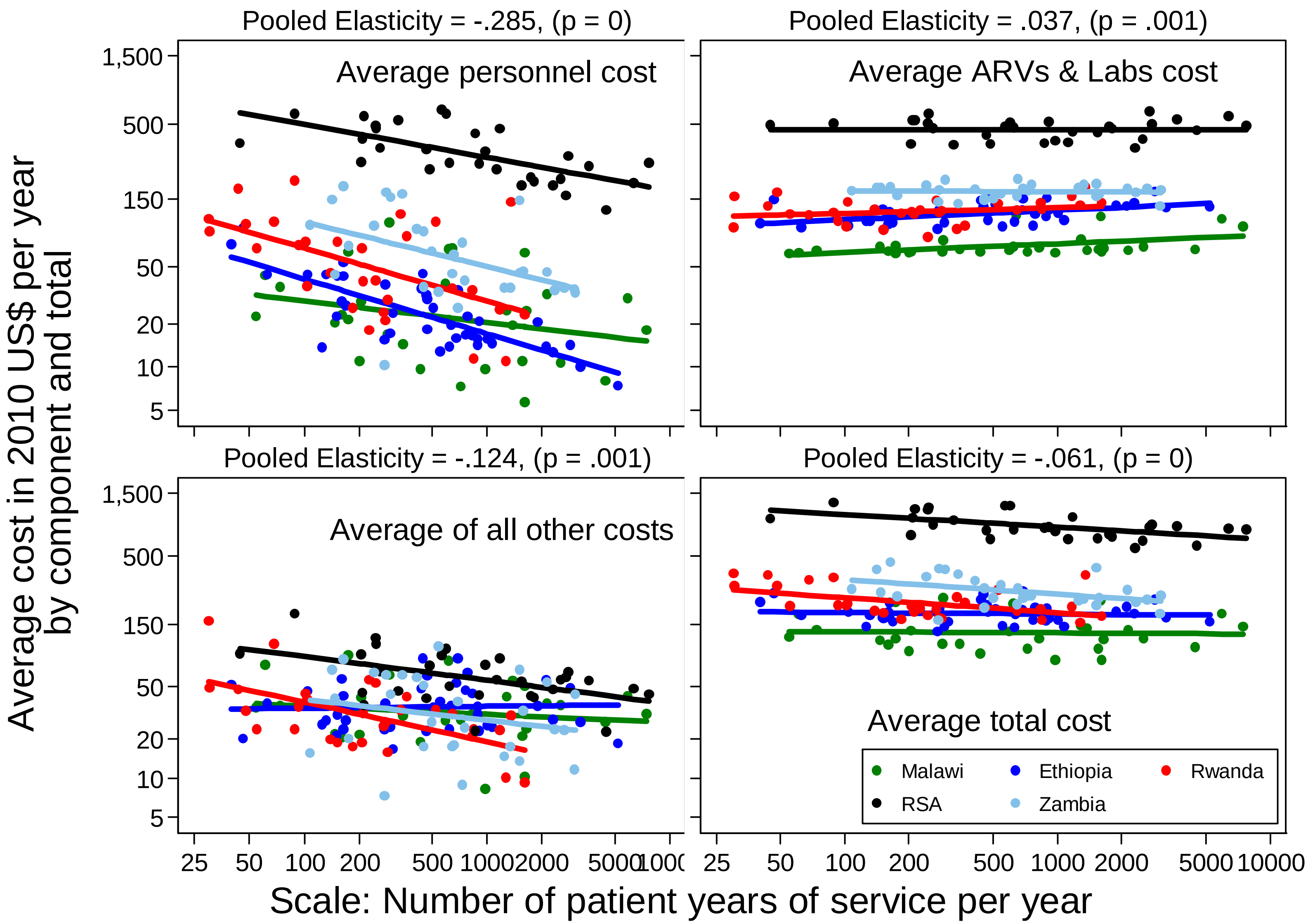


For the 161 facilities sampled in the five-countries

Variation to be explained



This study: Scale economies except ARVs & Lab



EXPLAINING COST VARIATION BY COMPONENT

Our methods (1)

- We attempt to explain variation in average cost and its components across the sample of 161 facilities in five countries.
- Because this is observational data on a random sample across five countries:
  - The data vary in quality and completeness from one facility to the next
  - Some potentially interesting variables are too frequently missing to include in the analysis.
  - Some facilities must be omitted from the analysis because they have too many missing or extreme variables
  - With only 30-40 observations per country, we have limited statistical power to analyze the countries individually

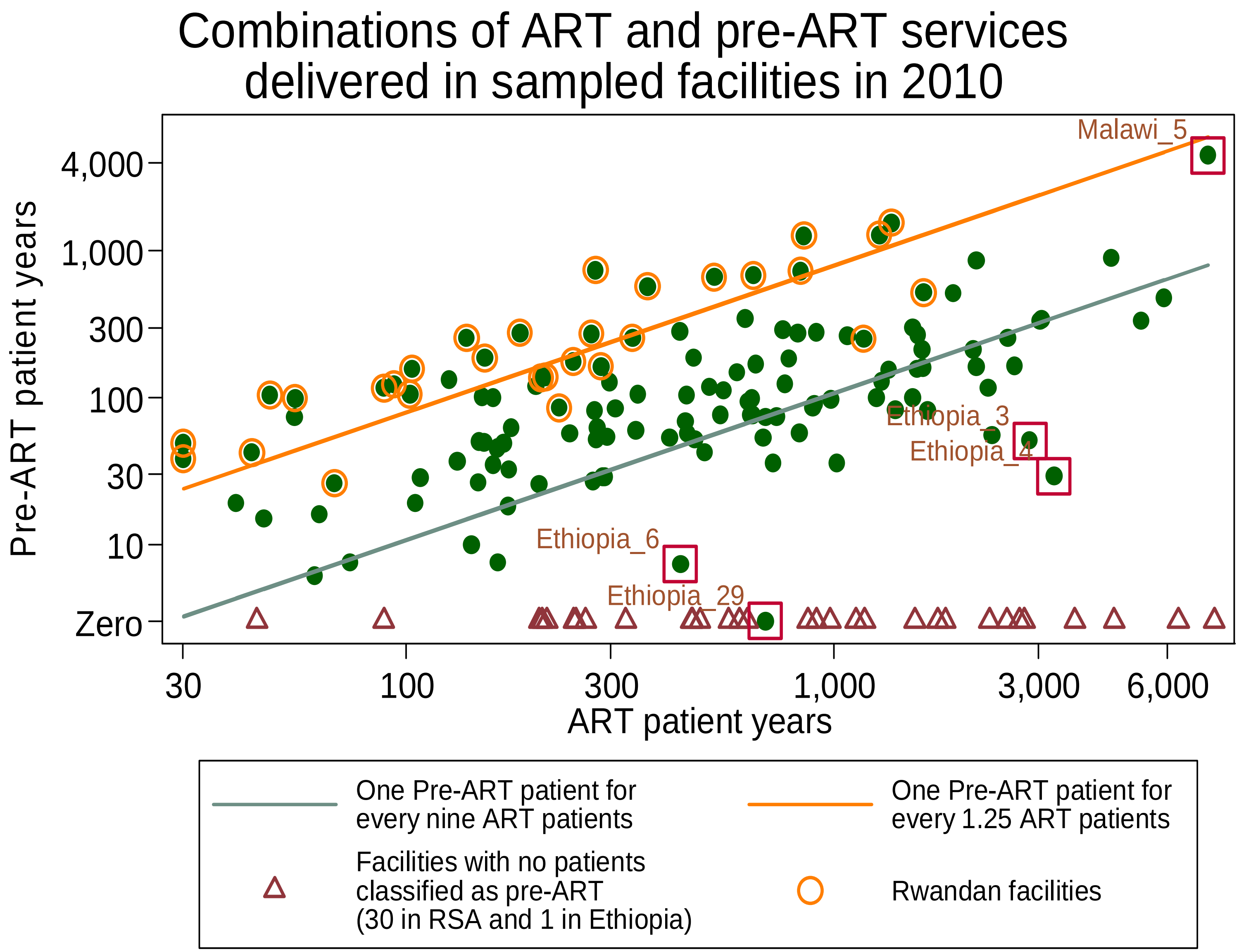
Our methods (2)

- Because this is observational data on a random sample across five countries:
  - With observational data, multiple regression offers more hope than bivariate analysis of revealing whether an “explanatory” variable affects average cost or its components.
  - Therefore we mainly present the results of multiple regressions.
  - In these multiple regressions, even a strong associations between one of our “explanatory” variables and an average cost component does not reveal a causal relationship. Rather it suggests a causal <u>hypothesis</u>, which could be tested by an experiment or pilot program.

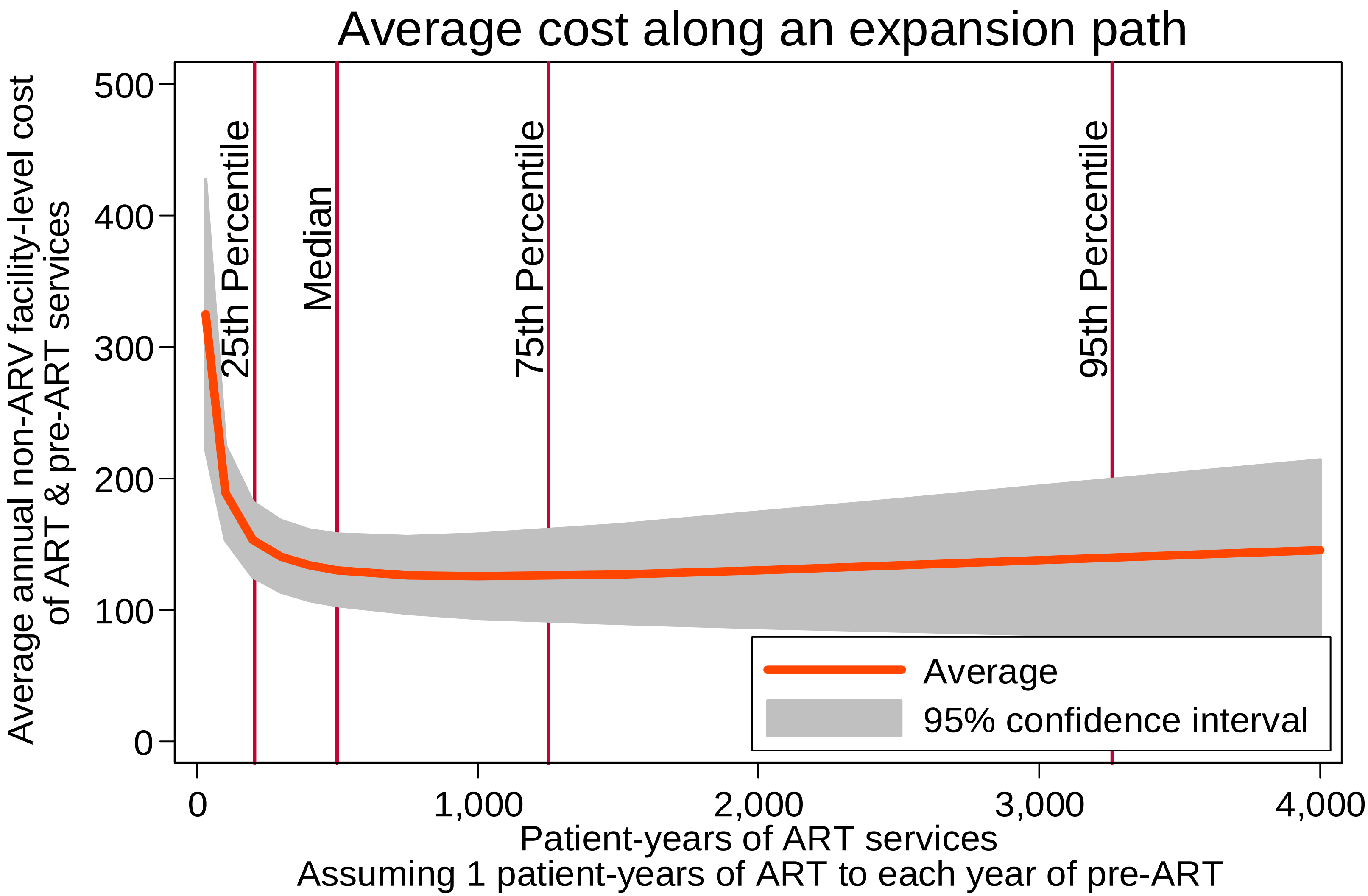
Our methods (3)

- Our objective is to embed an analysis of efficiency variation in Rwanda within an overarching structure common to the five countries
  - We separately analyze the cost of ARV's and all other operating cost of ART and pre-ART patients
  - We estimate a parsimonious joint cost function that controls only for the major structural causes of cost variation: scale and factor prices
    - We estimate a translog cost function on data from all five countries
    - The dependent variable is the total non-ARV cost of both ART and pre-ART
    - We explain more than 95% of the variation in the total cost of producing pre-ART and ART services by the quantity of each of these services produced and a set of 5 prices variables
  - We derive an estimated inefficiency score for the subset of 130 firms that produce both pre-ART and ART. (We have excluded 31 facilities, 30 in RSA and 1 in Ethiopia.)
    - We use the method of "corrected ordinary least squares"
  - For each of the four countries, we use multiple regression to explore the association between a set of determinants and the efficiency scores of firms in that country
  - Finally we project the estimated impact of a 50 percentile change in each determinant on both cost and patient retention

Facilities differ greatly in the amount of pre-ART services they deliver

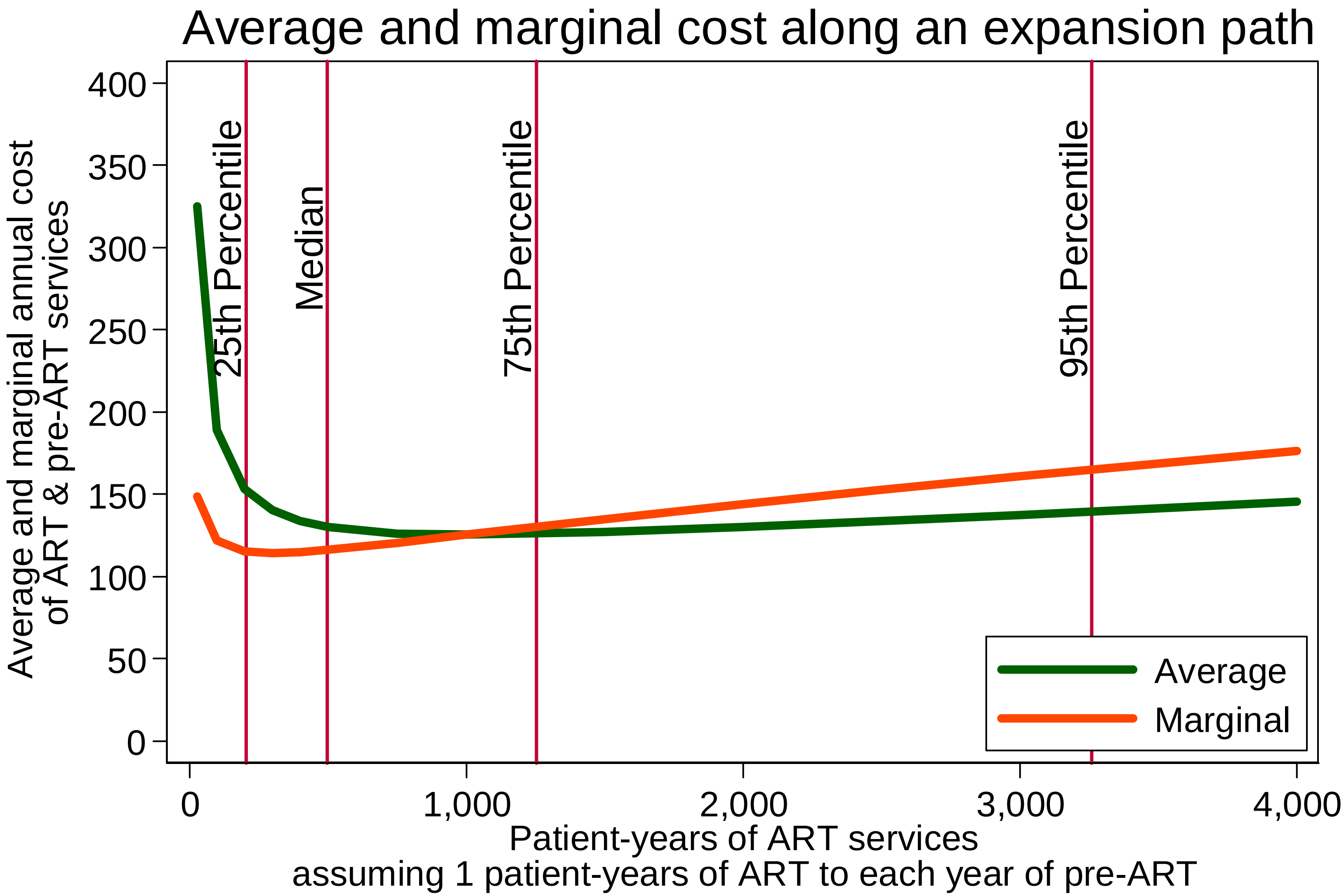


Average total non-ARV cost declines with the number of ART person-years served



Below the median output, a 100% increase in output is associated with a 67.5% increase in cost

The marginal cost of an additional patient is greater in larger facilities



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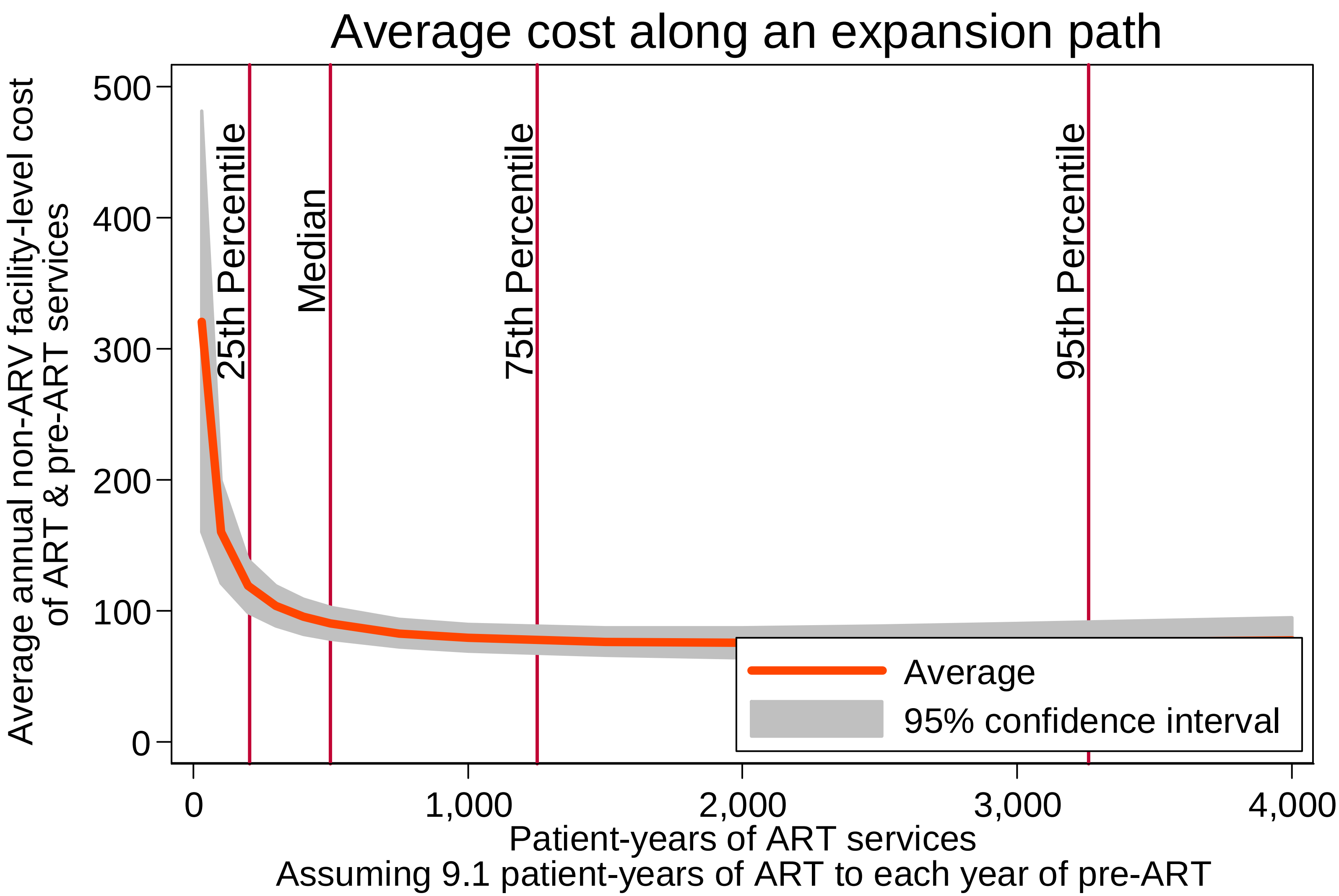
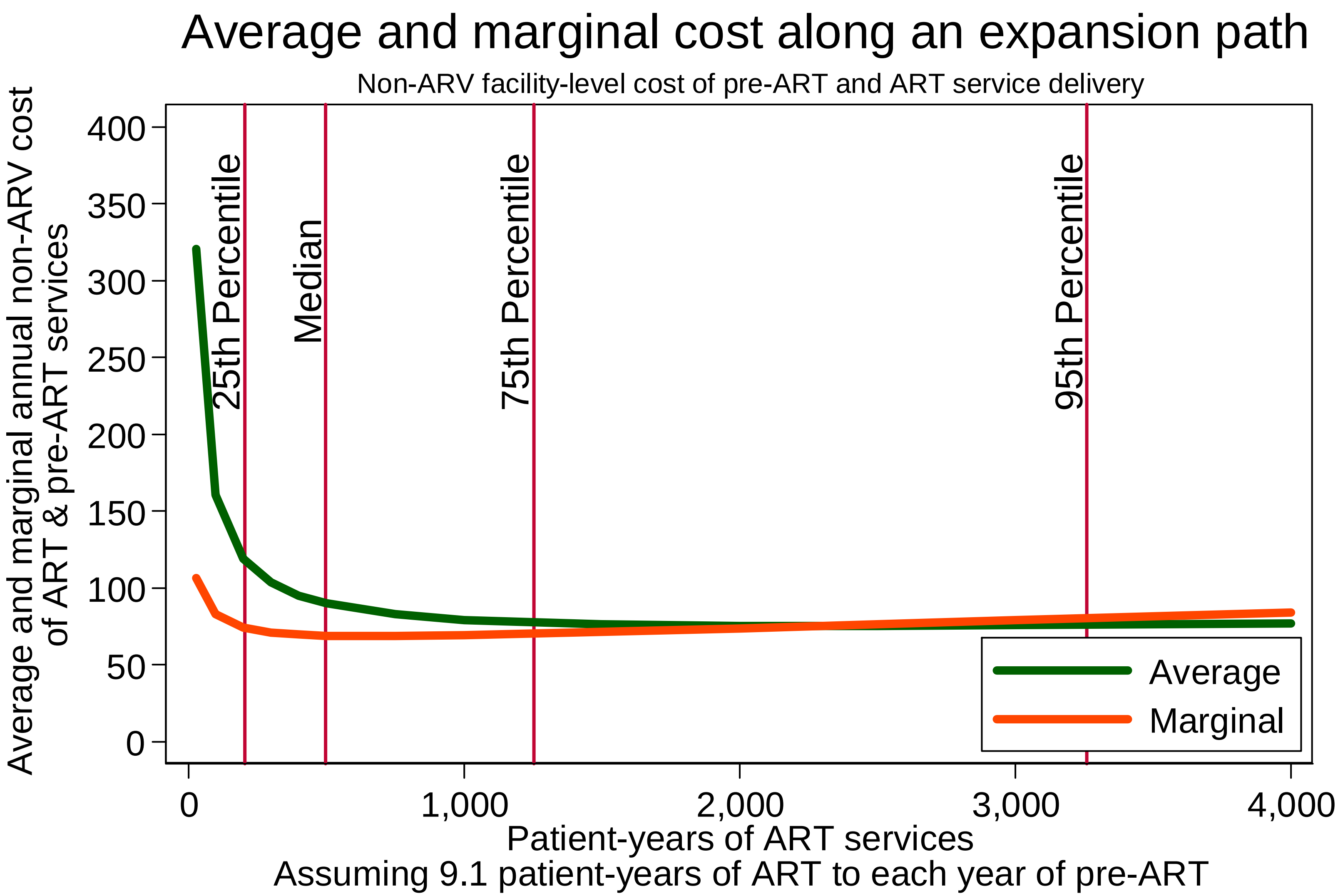


Below the median output, a 100% increase in output is associated with a 53.8% increase in cost

The marginal cost of an additional patient is greater in larger facilities



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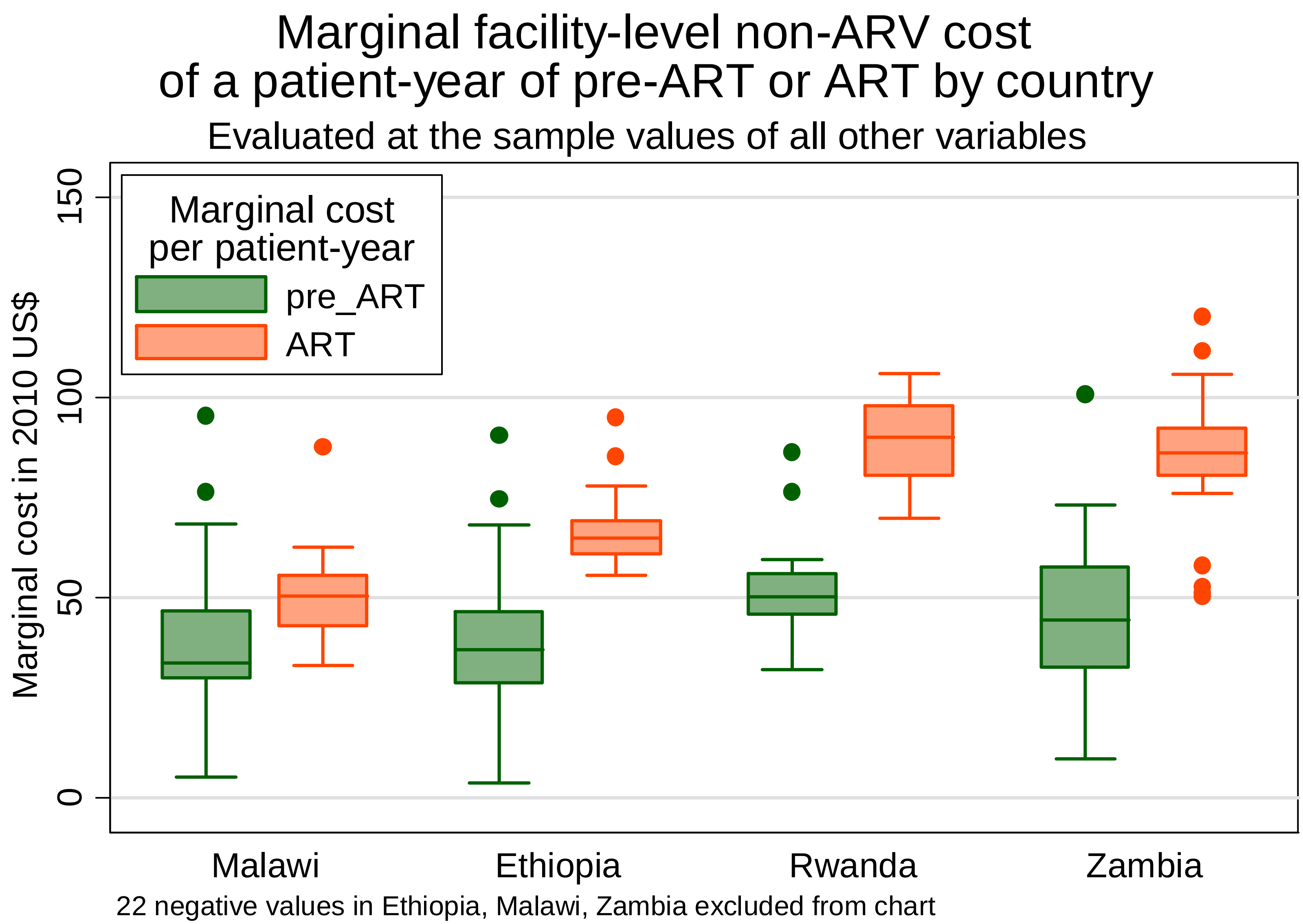
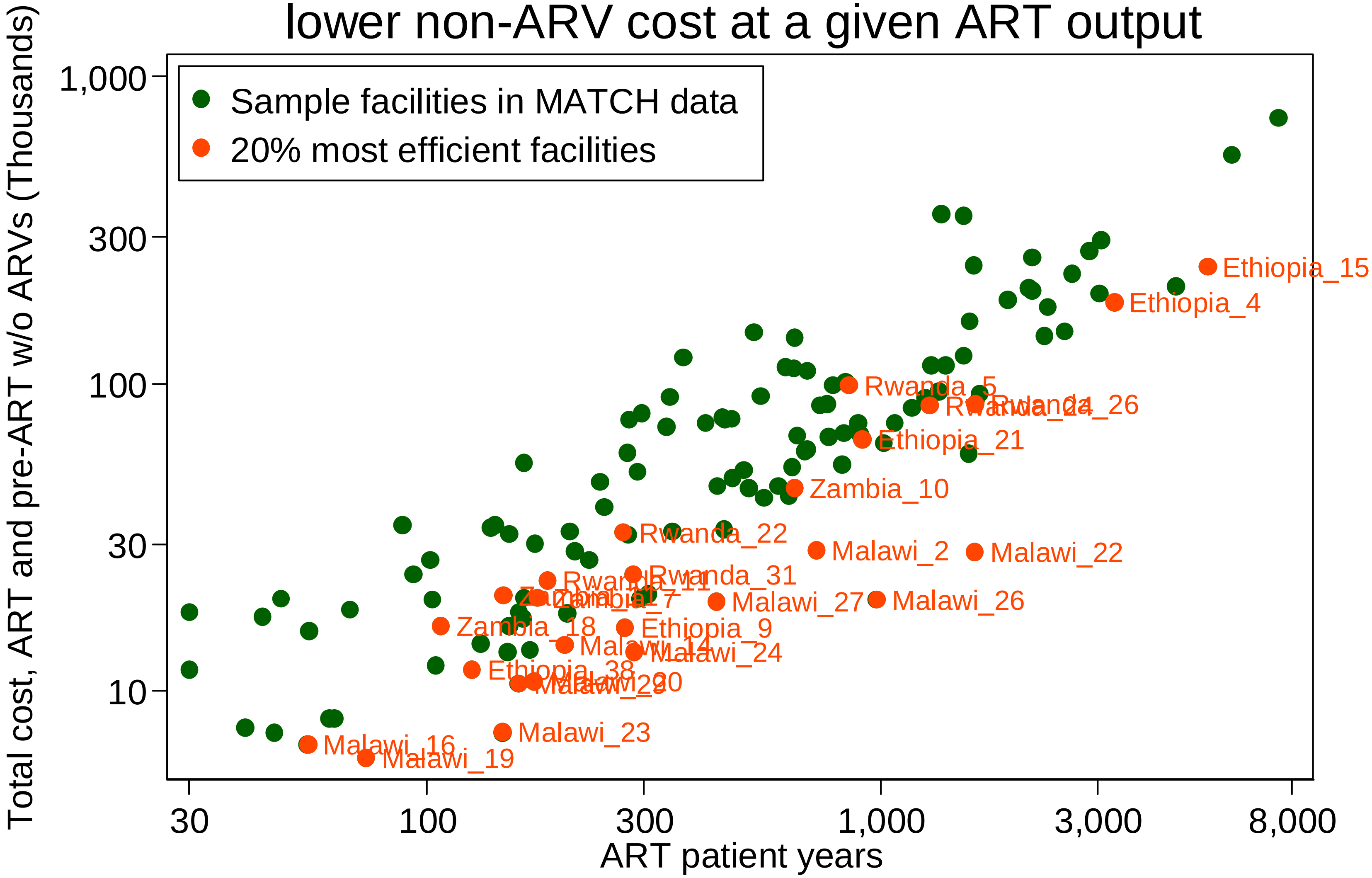
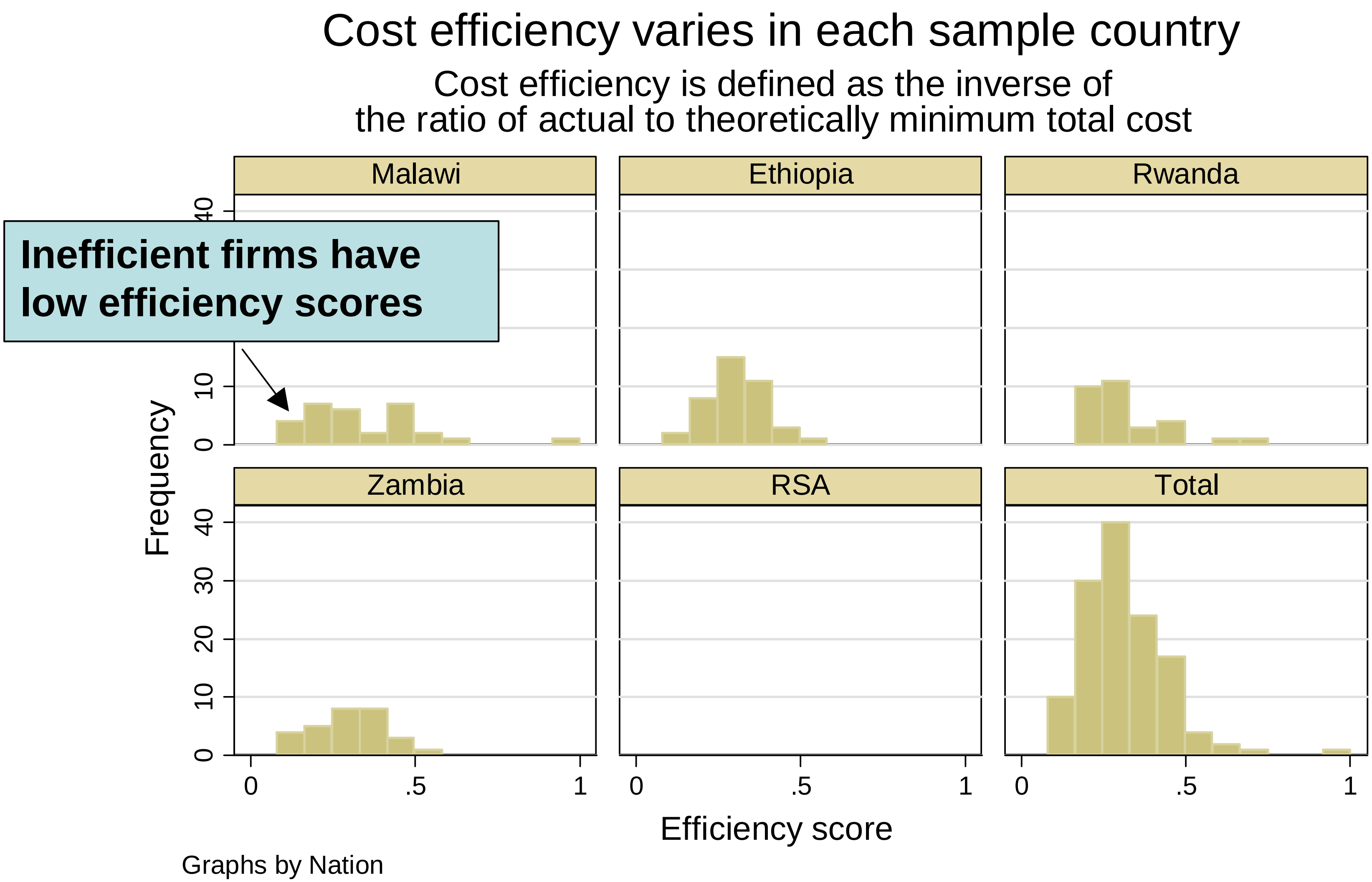
The estimated cost function provides the marginal costs of service delivery



More efficient facilities tend to have lower non-ARV cost at a given ART output



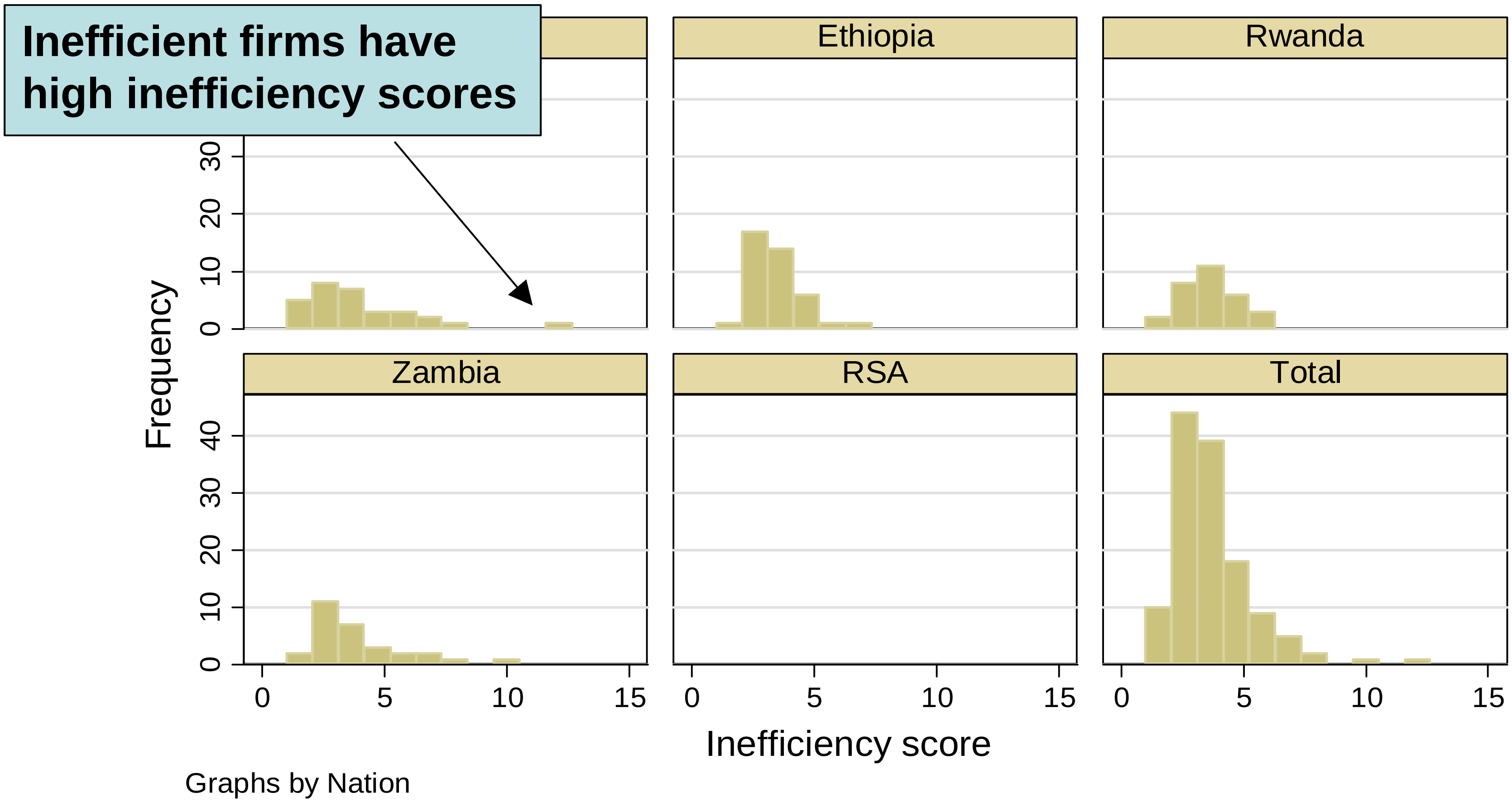
Efficient firms in all 5 countries



Our second stage analysis is to explain the inefficiency score

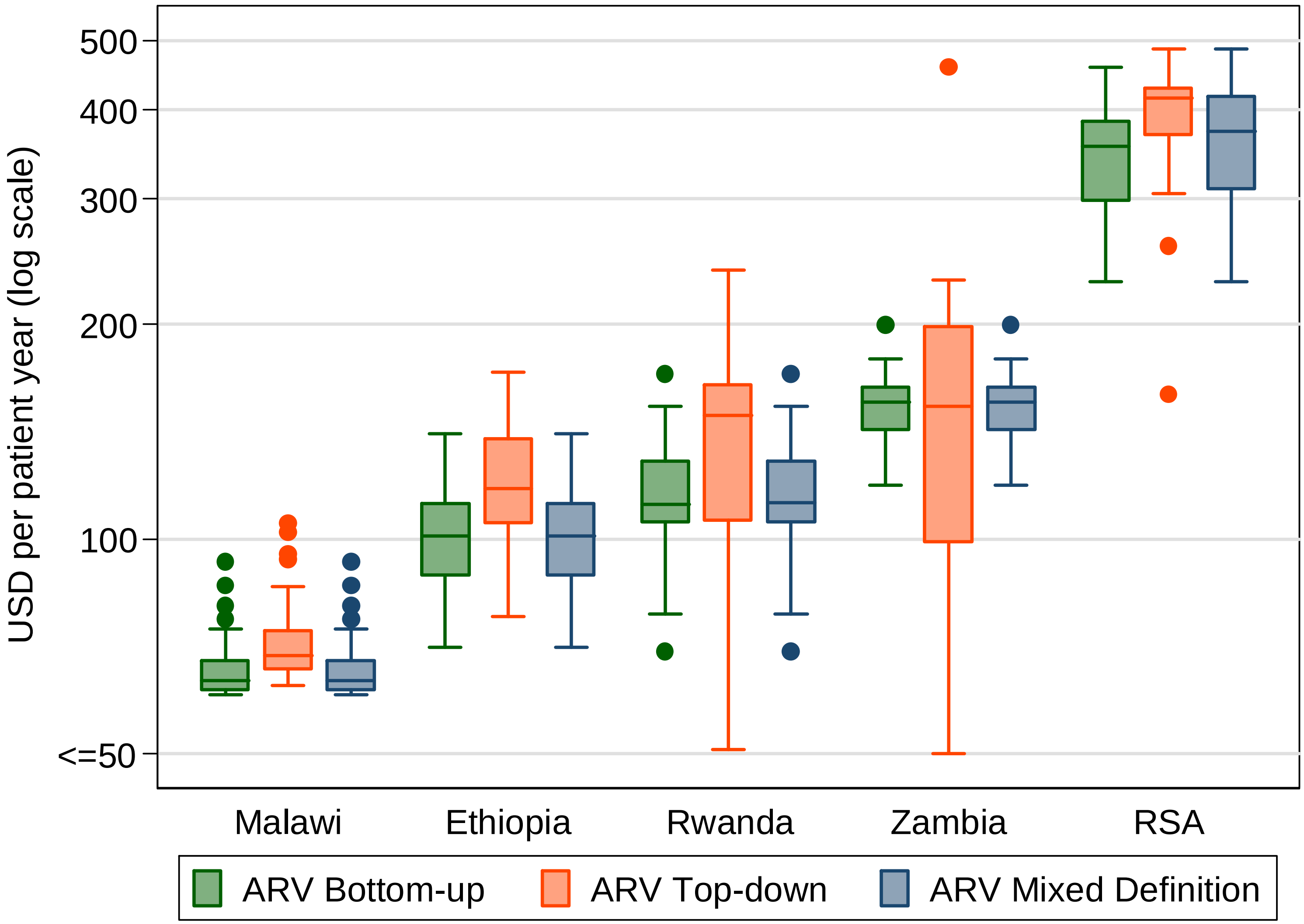
Cost inefficiency varies in each sample country

Cost inefficiency is defined as
the ratio of actual to theoretically minimum total cost

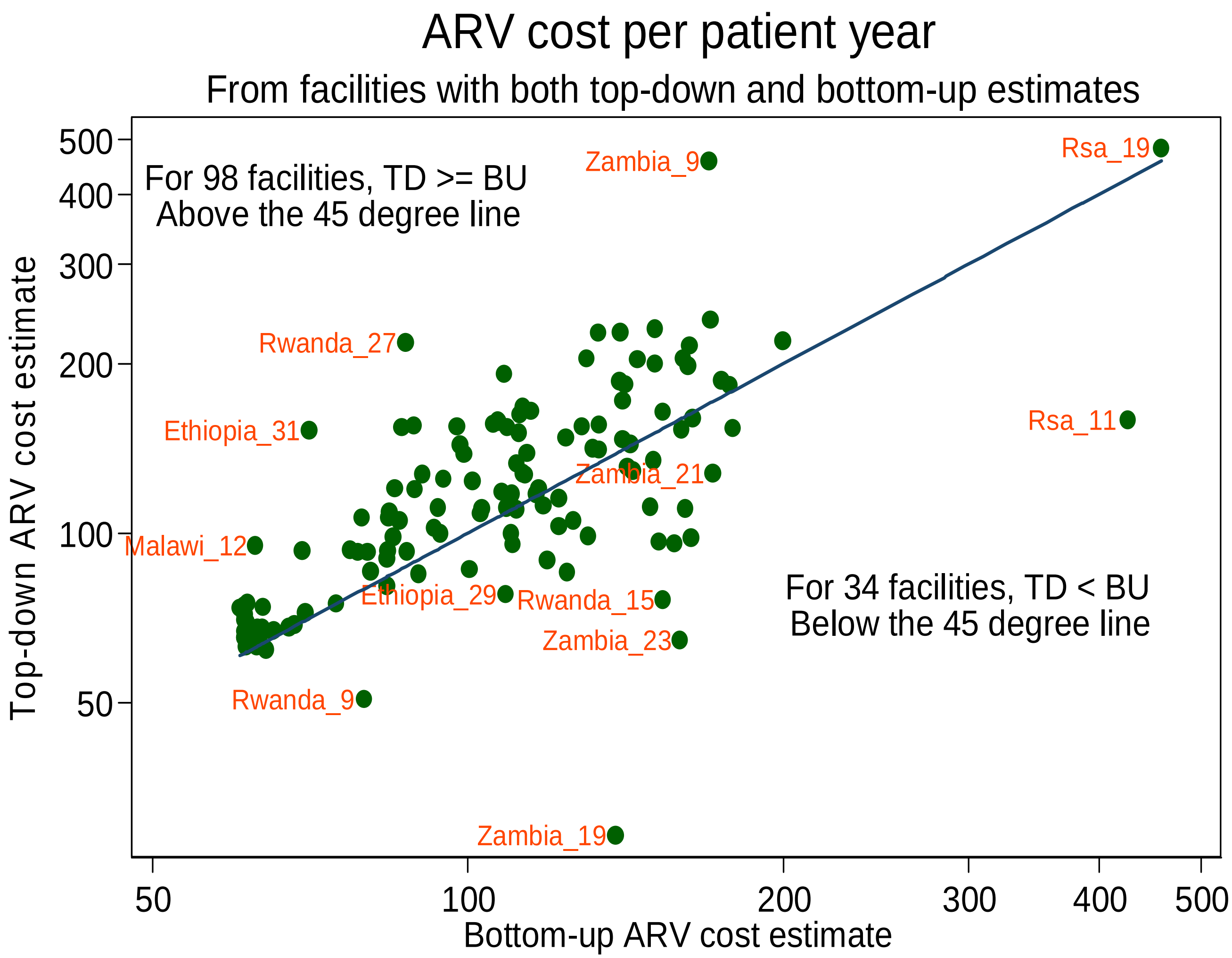


CLUES TO EFFICIENCY IN THE RATIO OF BOTTOM-UP TO TOP-DOWN ARV COSTING

Alternative estimates of ARV costs



TD estimates may be more accurate for most facilities



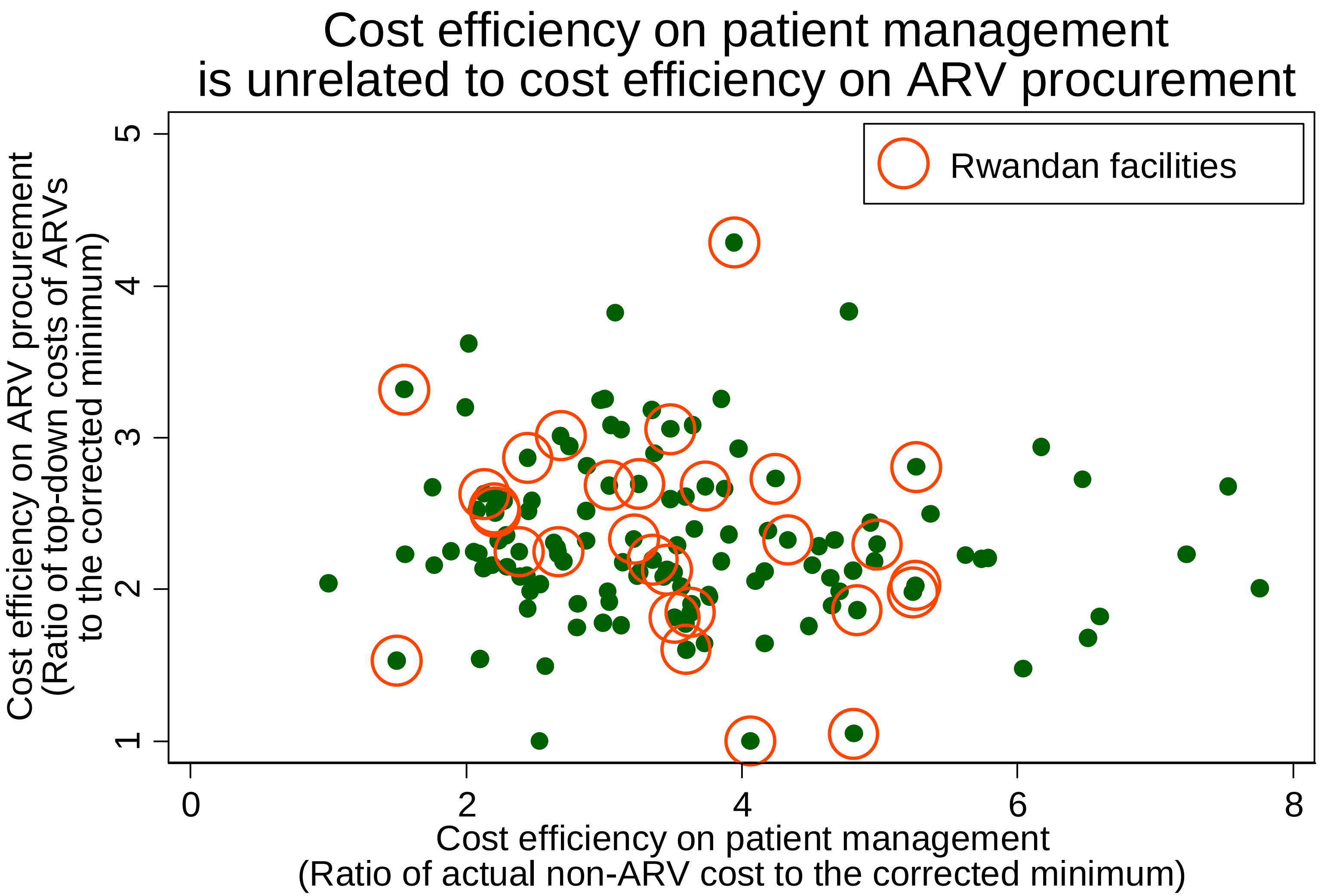
Reasons for difference between Top-Down and Bottom-up calculation of drug costs

- Possible sources of a higher TD/BU ratio
  - There is wastage or pilferage so the stock cards show that a facility received more drugs than were required by the patients.
  - The facility does not accurately record all legitimate transfers of drugs to other facilities
- Possible sources of a lower TD/BU ratio
  - There are stock-outs in the facility so even though bottom-up costs suggest patients should have received more drugs, the top-down information shows that the facility did not have adequate drugs
  - The facility receives drugs at a cheaper price than suggested by the price of regimes in national estimate.
  - The facility does not accurately or systematically record all receipts of drugs.

Some variables predict the TD/BU ratio

	log(TD BU Ratio)	
	With country dummies	Without country dummies
Some PEPFAR support	0.294***	0.117**
	(0.077)	(0.054)
Percent of patients on 2L	0.053***	0.048**
	(0.020)	(0.021)
Any stockouts?	-0.069	-0.076
	(0.050)	(0.052)
Facility Dedicated to HIV (dummy, 1=Yes)	-0.257***	-0.331***
	(0.091)	(0.092)
Distance of the facility to the capitol, relative to the farthest from capitol	0.044 (0.092)	0.169* (0.090)
Number of observations	126	126
R2	0.294	0.193
Country dummies	Included	Not included

Comparing the inefficiency scores on the ARV and non-ARV components of total facility-level cost

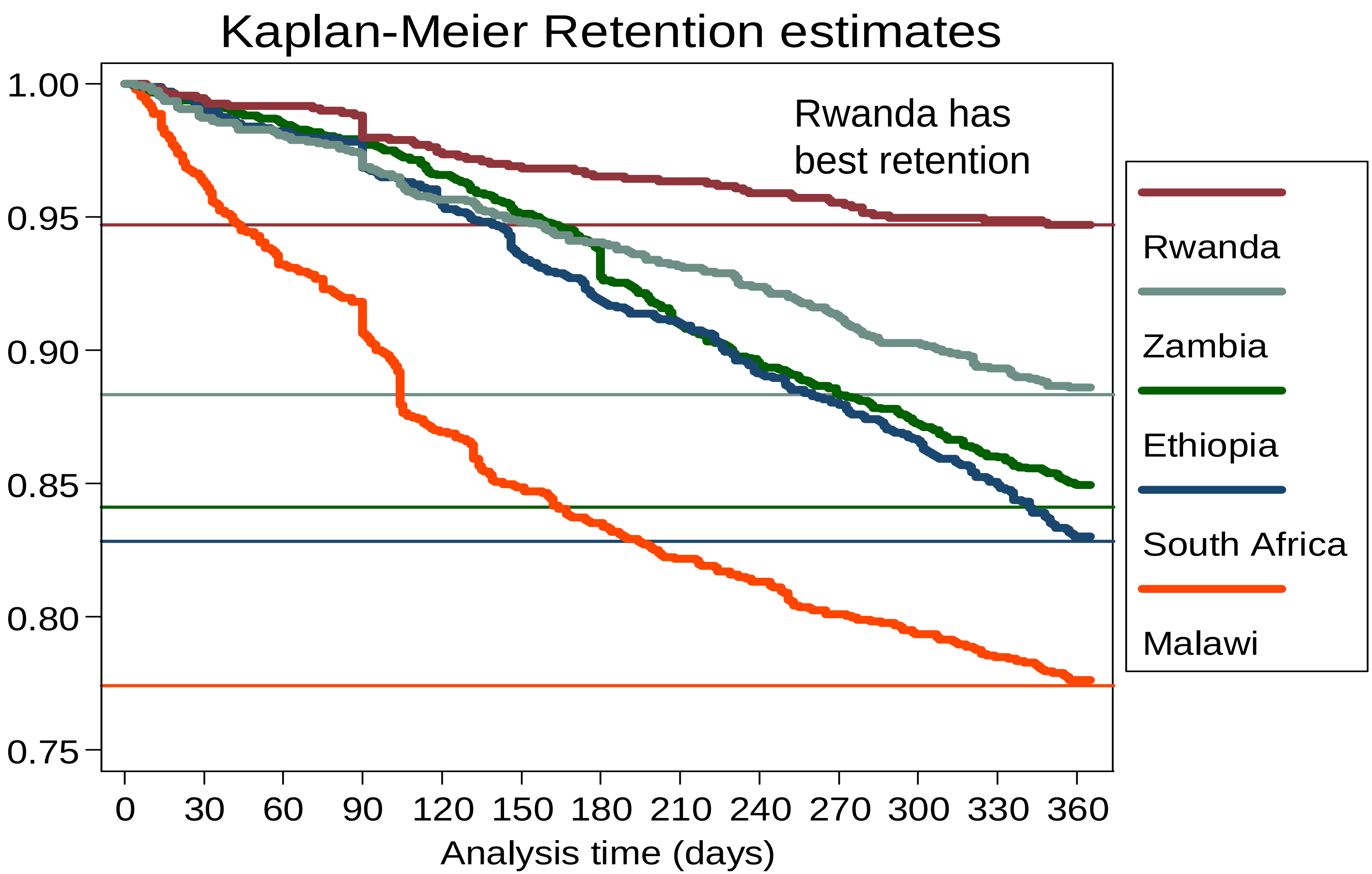


Cost inefficiency scores estimated by corrected ordinary least squares

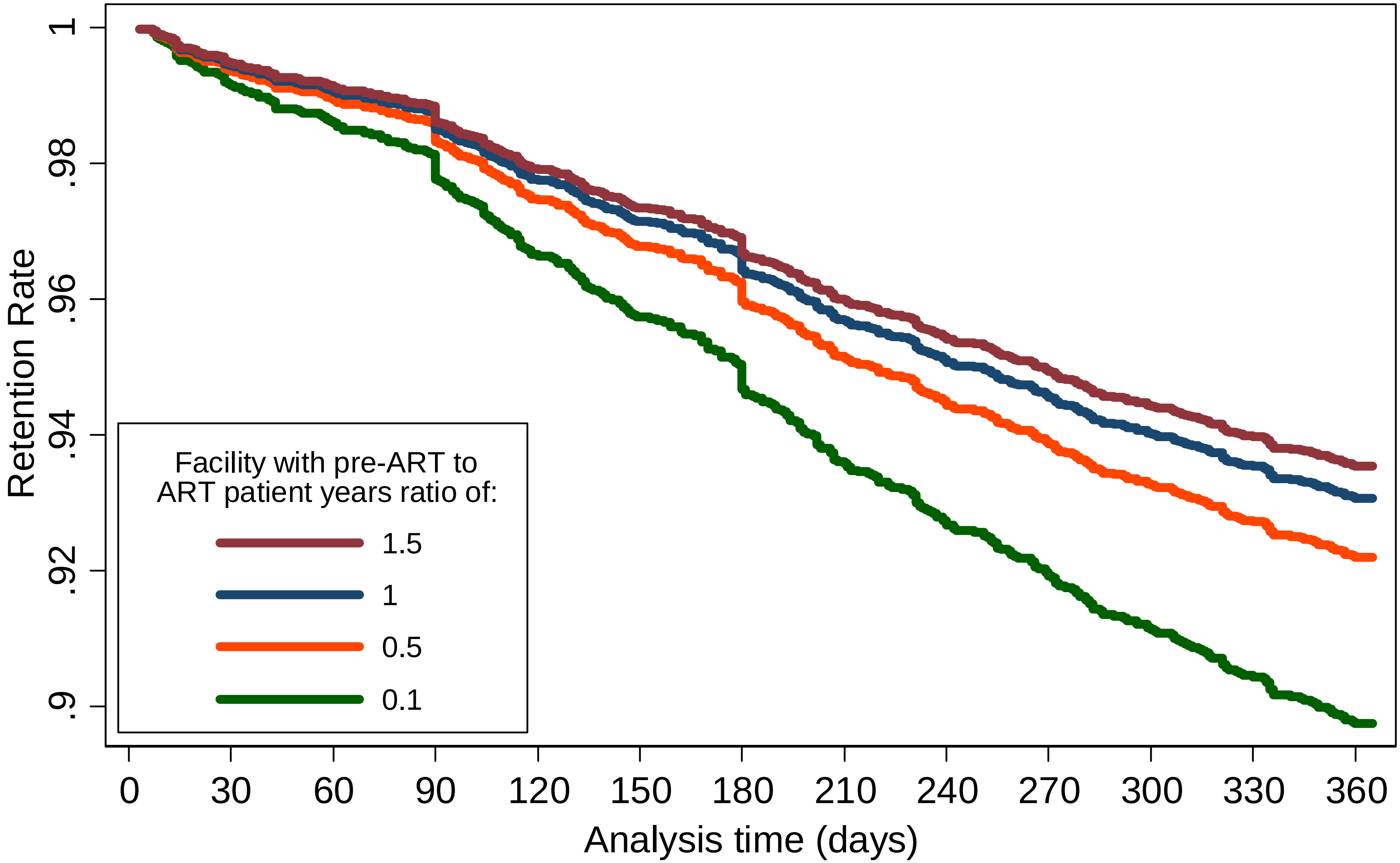
EXPLAINING PATIENT RETENTION

Unadjusted retention by country

7,727 patients in 160 facilities



Effect of a larger Pre-ART program on retention



Note: Graph is based on specification (6)

Putting the costs and benefits together