The impact of integrated production on the efficiency of HIV prevention services: Econometric estimates from the ORPHEA project in a four country sample

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Motivation

- Synergy between PMTCT and non-HIV services as countries assume more responsibility over HIV service delivery
- Improving efficiency through economies of scope
- Objective: integration of PMTCT with non-HIV services
- Research question: What effects does "integration" of PMTCT with non-HIV services have on cost of those services?

How can we achieve economies in the production of health services?

- <u>Economies of scale</u> is the cost advantage that arises from increasing the level of production (output). The greater the quantity of output, the lower the per-unit cost because the fixed-costs are spread out over a larger number of production units (e.g. health clients).

- <u>Economies of scope</u> occur when given amounts of two or more outputs can be produced together in the same production facility for less cost than would be required to produce the two outputs in separate production processes.

The ORPHEA project

One-year retrospective data collection micro-costing

- Three interventions HTC, PMTCT, VMMC
- Four countries: Kenya (2011), Rwanda (2012), South Africa and Zambia (2011-2012)
- Multi-stage sampling techniques (n=276 facilities)
- Outputs: all services produced in the previous fiscal year
- Inputs: staff, essential recurrent inputs and services, capital, training and supervision
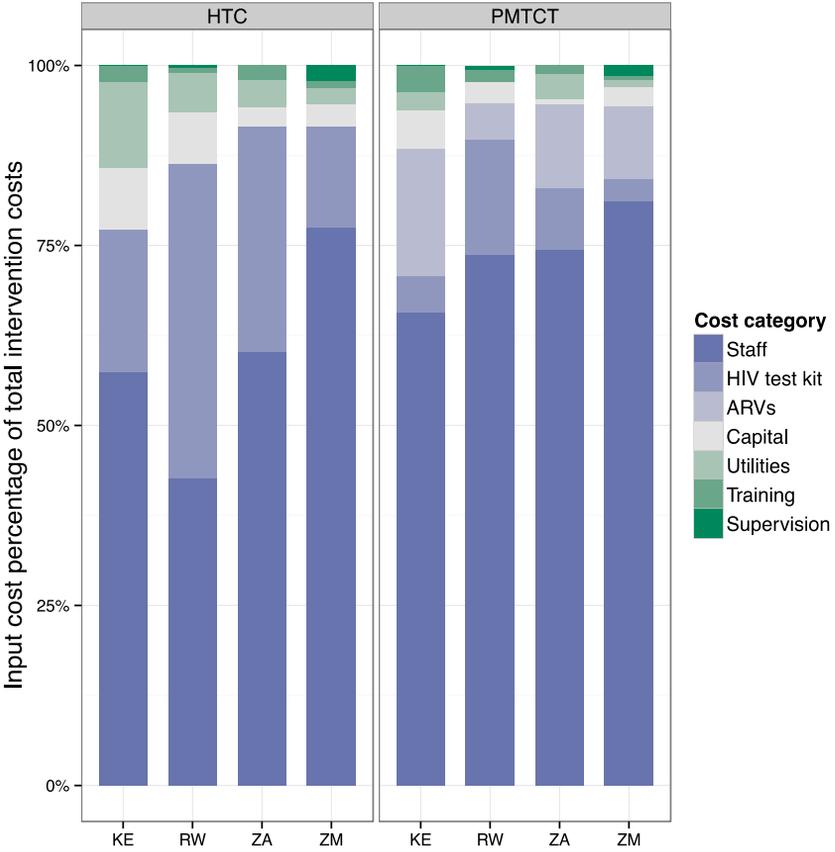
Facility-level

- Staff roster
- Drugs and supplies
- Utilities
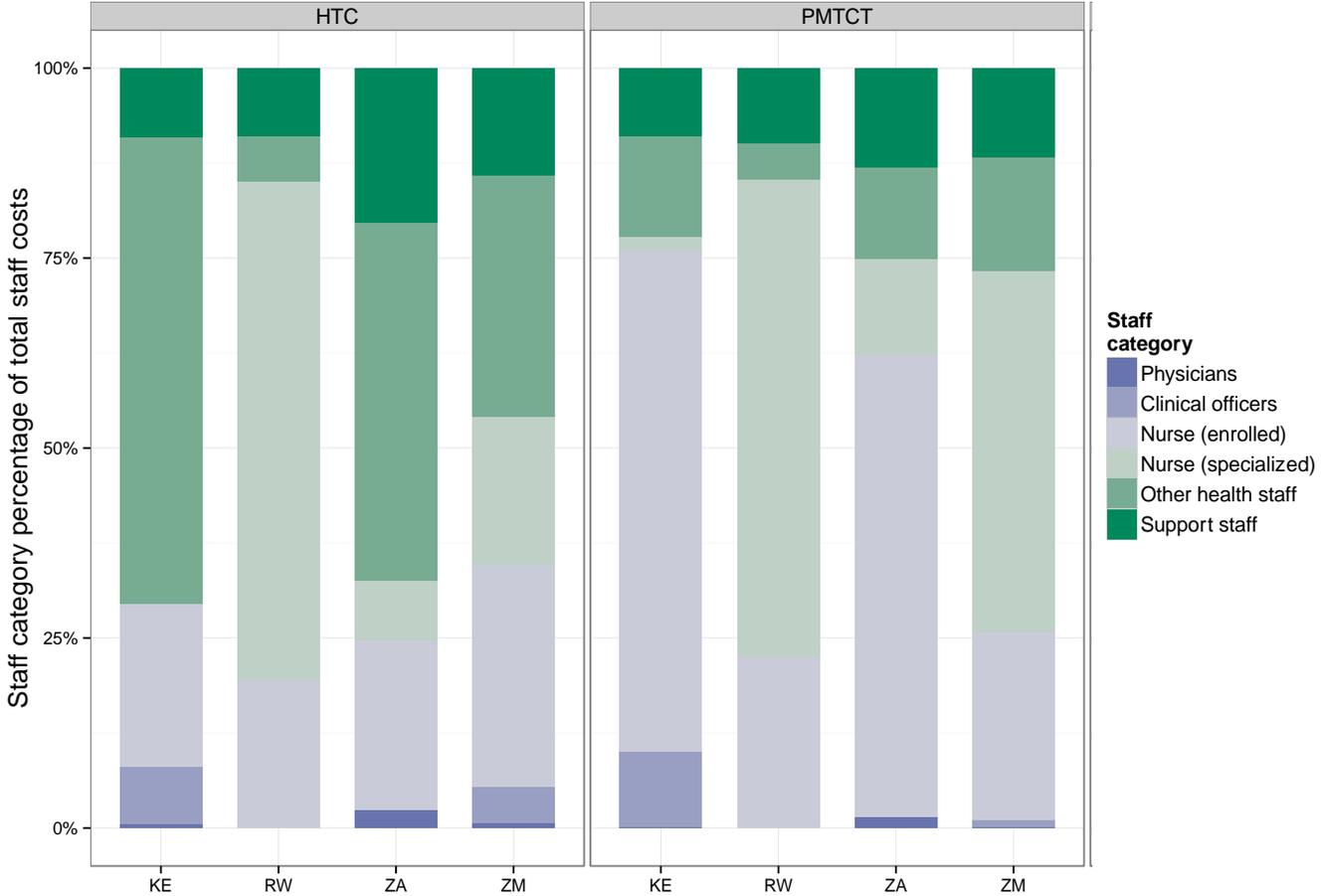- Equipment and buildings

National-level

- Salaries
- Prices of supplies (HIV test kits, ART)

Total cost breakdown

- ▸ Staff is the main cost driver for the three interventions – between 40% and 80%
- ▸ Followed by essential supplies:
  - - HIV test kits
  - - ARVs

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Staff costs breakdown

Definitions

- The analytical sample include 209 facilities that provide PMTCT services
- Total cost*
  - The sum of salaries of staff that intervened partially of full-time in the provision of HIV services during the costing year.
- PMTCT clients
  - Pregnant women who tested positive for HIV and were enrolled in either Mono, Dual, Triple therapy, or life-long ART *during the costing year.*
- Non-HIV clients
  - The sum of inpatient + outpatient clients.
- Price of staff*
  - Hourly wage rate of five staff categories: Doctors, specialized nurses, registered nurses, counselors and indirect staff.

* Adjusted by Purchasing Power Parity (PPP)

Estimation strategy to identify economies of scope

- One way to identify if health facilities that produce two outputs (PMTCT & non HIV) benefit from economies of scope is to estimate a total cost function which allows for interactions between the two outputs. Using facility-level data from the ORPHEA study, we propose a simple cost function as follows:*

$$TC = a + b * PMTCT + c*non\text{-}HIV + d*(PMTCT* non\text{-}HIV) + X * (prices) + Z * (country)$$

- where PMTCT and non-HIV represent the quantities of these two categories of services delivered during the costing year and TC is total cost. In this formulation, the marginal cost of an incremental unit of *PMTCT* service is:

$$b + d * non\text{-}HIV$$

- If *d* is negative, the production process benefits from economies of scope. Otherwise, a positive value of *d* could indicate <u>dis</u>economies of scope and suggest that the two production processes would be more efficient in terms of their cost if kept separate.

* Several flexible functional forms were tested (Translog, Generalized Leontief)

Estimation

- Estimation of a total cost function that depends of quantities of output and input prices.
  - Plus *N-1* ancillary equations (cost shares) using Seemingly Unrelated Regression (SUREG) techniques and imposing shape constraints.
  - Cost share of the *i-th* input is the percentage of total cost.
- Computation of predicted values of total cost.
- Graph predicted cost for every <u>combination of PMTCT and non-HIV output.</u>
- Estimate average cost (AC) and marginal cost (MC) curves.

Results

Summary statistics of costs and outputs

	Mean	Median	S.D.
Annual staff cost			
Doctors	4,555	0	10,456
Specialized nurses	27,695	14,533	39,613
Nurses	24,554	3,037	35,801
Health staff[1]	18,115	2,996	36,900
Indirect staff[2]	8,574	1,871	13,921
Total annual staff cost	83,495	51,262	88,367
Number of clients			
PMTCT[3]	112	31	211
Non-HIV[4]	6,772	2,550	12,547

Notes: (1) The 'health staff' category includes counselors, community health workers, social workers, psychologists, and lab technicians; (2) the 'indirect' category includes administrative and support staff; (4) Pregnant women who tested positive for HIV and were enrolled in either Mono, Dual, Triple therapy, or life-long ART during the costing year; (5) Sum of inpatients and outpatient clients (weighted by their relative contribution to total annual staff costs.
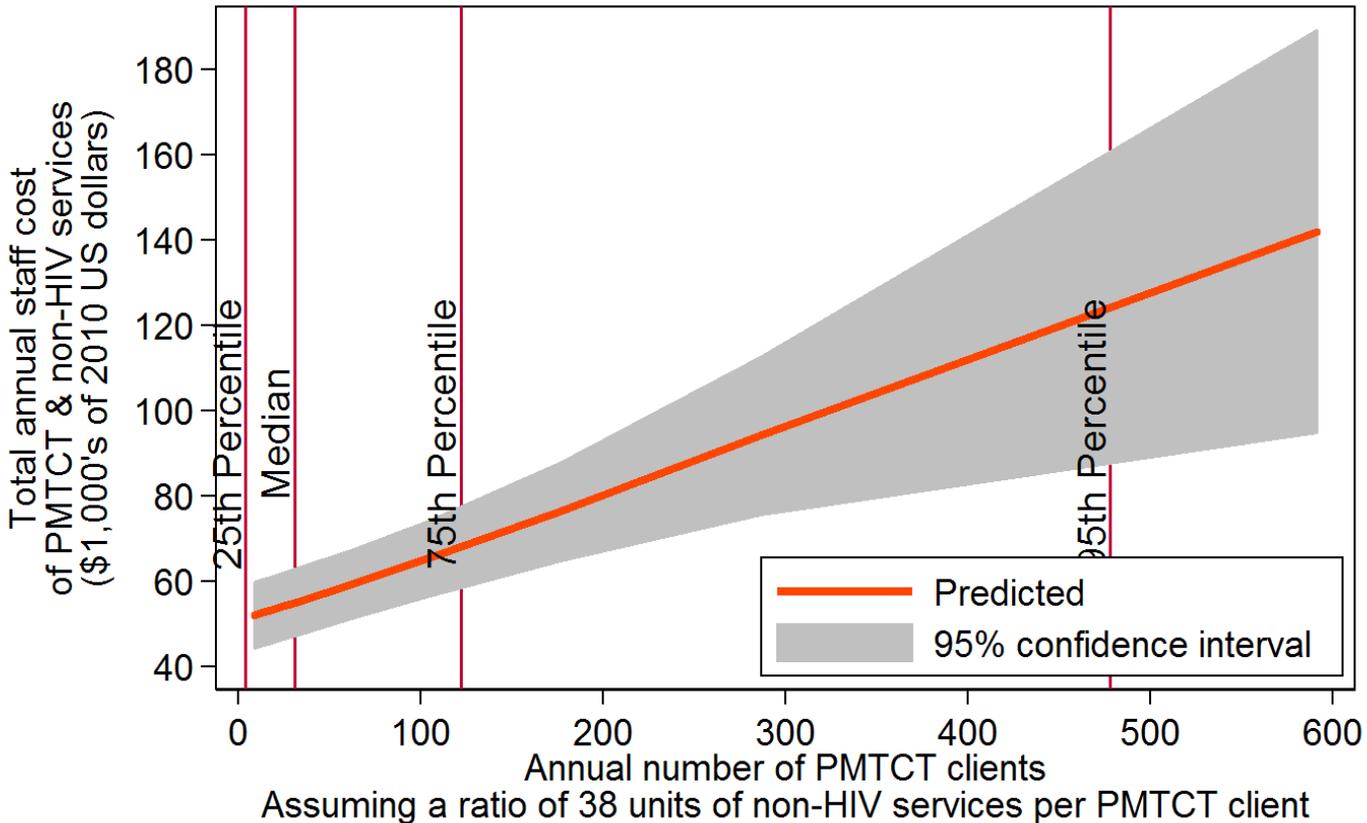
Regression results

y = Total staff cost (Log)

	β
PMTCT clients[1]	1.590***
Non HIV clients[1]	0.025***
PMTCT clients $\times$ Non HIV clients	-0.036***
Country fixed effects[2]	
Rwanda	0.562***
South Africa	-2.496***
Zambia	0.675***
Constant	9.523***
Observations	209
R-squared	0.629

Notes: (1) Thousands of clients (2) Reference level is Kenya;
the full model controls for input prices and their interactions
output not shown); *** p<0.01, ** p<0.05, * p<0.1.

- ‣ The null hypothesis of no interaction effect is strongly rejected (χ^2 = 17.7)

- ‣ This finding is indicative of economies of scope

Total facility-level staff cost along an expansion path

Y-axis: Total annual staff cost of PMTCT & non-HIV services ($1,000's of 2010 US dollars)

X-axis: Annual number of PMTCT clients

Vertical lines labeled: 25th Percentile, Median, 75th Percentile, 95th Percentile

Legend:
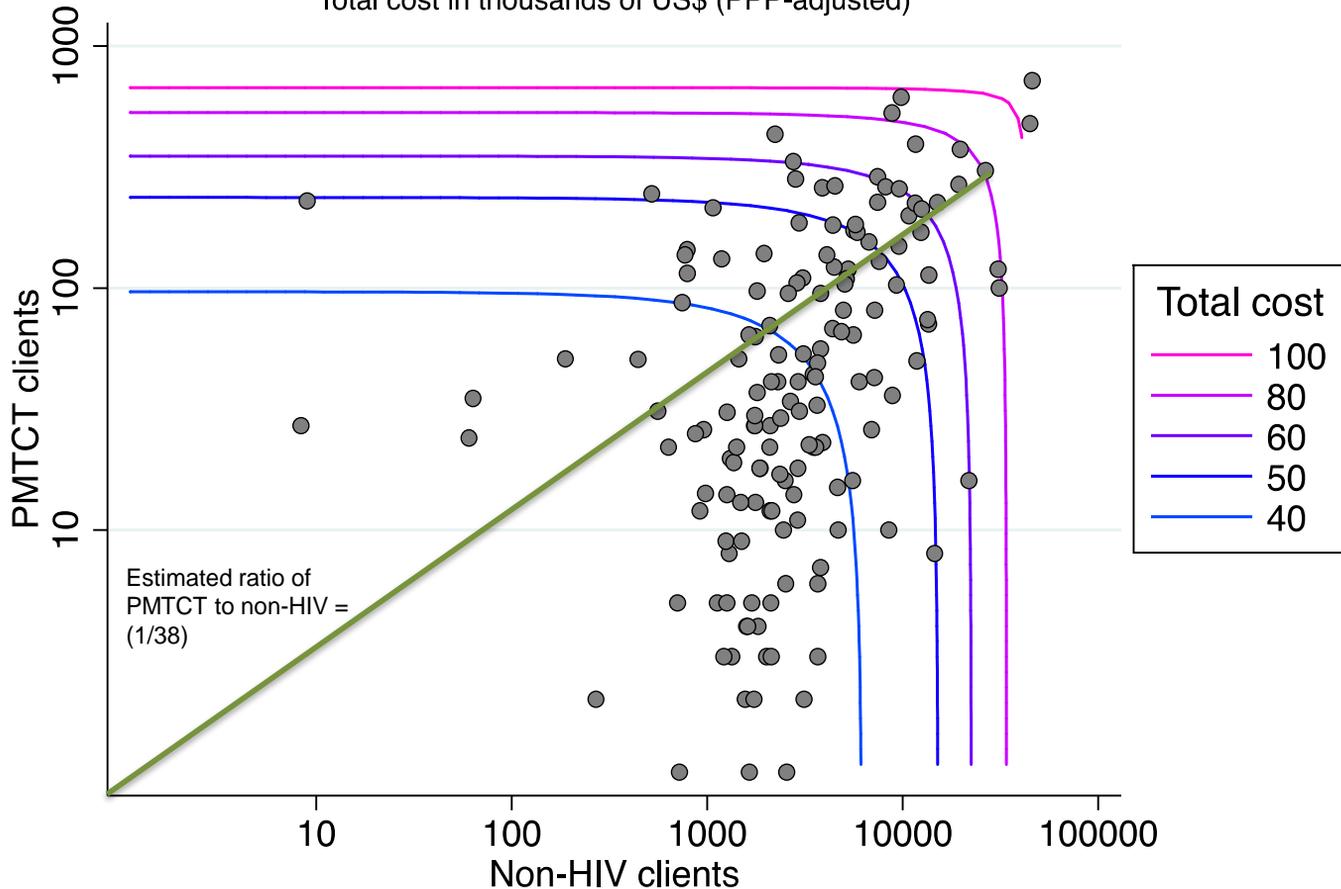- Predicted
- 95% confidence interval

Assuming a ratio of 38 units of non-HIV services per PMTCT client

Below the median output, a 100% increase in output is associated with a   3.6% increase in cost

PMTCT and non-HIV Cost Function

Total cost in thousands of US$ (PPP-adjusted)
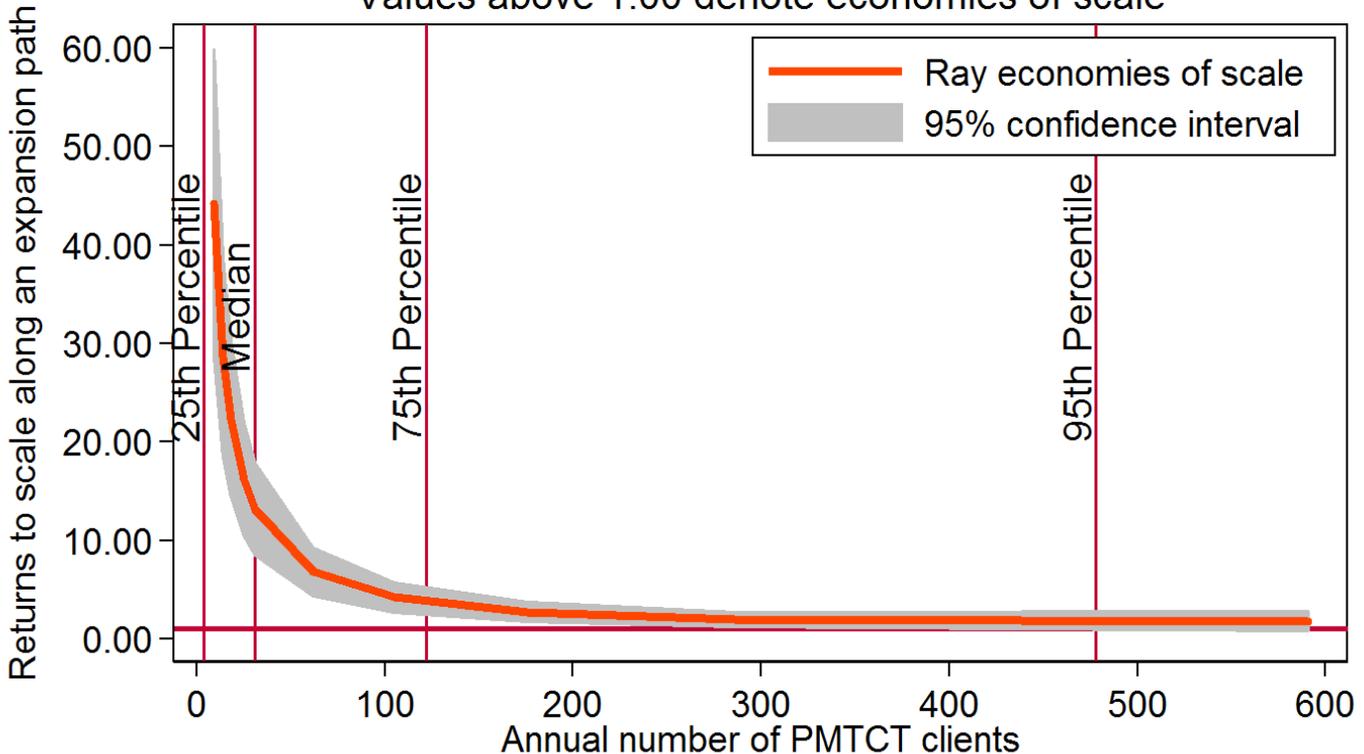
Average and Marginal cost along an expansion path

Facility-level staff cost of PMTCT and non-HIV service delivery

25th Percentile

Median

75th Percentile

95th Pe

Legend:
- Average
- Marginal
- 95% confidence intervals

Y-axis: Average and marginal annual staff cost of PMTCT & non-HIV services

X-axis: Annual number of PMTCT clients

Assuming a ratio of 38 units of non-HIV services per PMTCT client
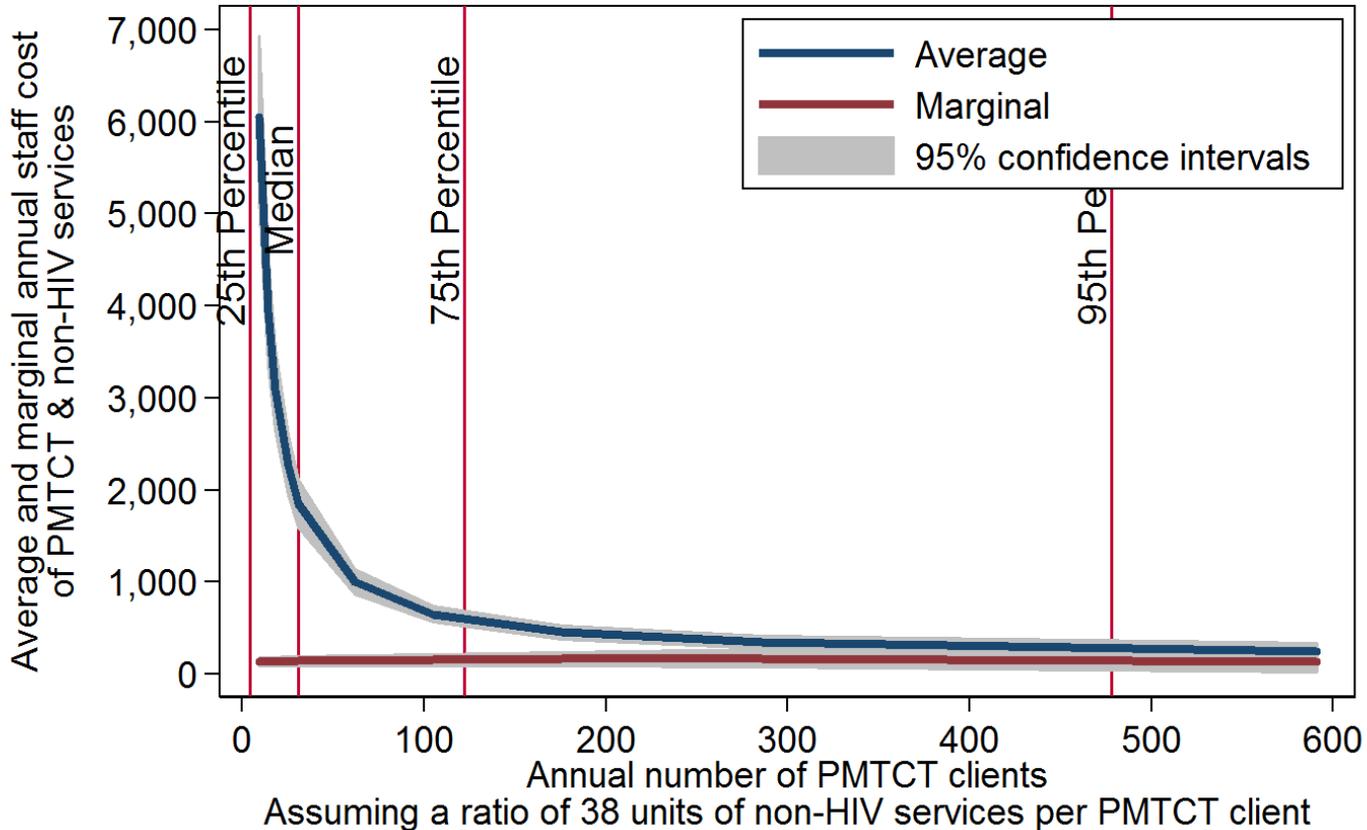
Below the median output, a 100% increase in output is associated with a 3.6% increase in cost

Ray economies of scale along an expansion path

Ratio of the increase in output to the increase in cost
Values above 1.00 denote economies of scale

Legend:
- Ray economies of scale
- 95% confidence interval

Y-axis: Returns to scale along an expansion path (0.00 to 60.00)

X-axis: Annual number of PMTCT clients (0 to 600)

Vertical markers: 25th Percentile, Median, 75th Percentile, 95th Percentile

Assuming a ratio of 38 units of non-HIV services per PMTCT client

Below the median output, a 100% increase in output is associated with a   3.6% increase in cost

Summary findings

- The ORPHEA data shows evidence of economies of scope.
- Big scale effects – particularly for small facilities.
- Below median output of PMTCT, doubling the number of clients would increase staff cost by only 4%, assuming a fixed ratio of 1:38.
- These findings have the potential to inform changes in service delivery.

Next steps

- Use more general flexible functional forms in order to understand how average cost varies under different curvature assumptions.
- Projection of additional scenarios considering different ratios of PMTCT clients to non HIV services.
- Identification of policy variables and other "cost shifters".
- Derivation of Allen-Uzawa partial elasticities of substitution among health inputs.
- Analyzing the relationship between 'quality' and costs variation.

Acknowledgements