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Modeling Internet Use in the Global Development Context:

Preliminary Findings and Future Directions

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Research in Brief

- Question
  - How do various markers of choice influence internet use?

- Justification
  - 2.6 billion offline [1]
  - Internet can expand capabilities [2]
  - Inquiry beyond economic factors needed [3]

- Method
  - Use regression analysis to identify significant relationships between internet use and array of factors identified using CA lens [4]

- Data Sources
  - Global data banks including UNESCO, UN, WHO, and World Bank

- Value
  - Results could offer insights to policymakers and development practitioners in the ICT4D space and beyond

[1] International Telecommunication Union, "Measuring digital development: Facts and Figures 2023," 2023. [Online].
[2] I. Oosterlaken, Technology and Human Development. Routledge, 2015.
[3] K. Salemink, D. Strijker, and G. Bosworth, "Rural development in the digital age: A systematic literature review on unequal ICT availability, adoption, and use in rural areas," J. Rural Stud., vol. 54, pp. 360-371, 2017.
[4] A. Sen, Development as Freedom. New York, NY: Anchor Books, 1999.

Background: ICT4D

- **ICT4D Definition and Scope** [5]
  - Information and Communication Technologies for Development (ICT4D)
  - Employs ICT as tools and goals for development
- **Role of Digital Integration** [9]
  - The "digital nervous system" of the world necessitates ICT in all development projects
  - Blurring distinctions between "developed" and "developing" in digital world
- **Critiques of ICT4D** [6]-[8]
  - Challenges in measuring ICT-based project outcomes
  - Debate over the effectiveness and necessity of ICT incorporation
- **Reframing ICT4D** [10]-[12]
  - Views ICT4D as expanding real freedoms, not achieving prescribed outcomes
  - Argues for conceptualizing ICT4D as expanding real freedoms rather than achieving prescribed outcomes
  - Importance of unintended outcomes in evaluating the value of ICT4D projects
- **Expanding Access as Instrumental Freedom** [2], [13], [14]
  - Access to ICT demonstrably critical to enhancing overall capabilities and freedoms, such as political, economic, and social freedoms

[5] G. Walsham, ICT4D 2018: New Themes for an Old Field, 2018.
[6] R. Harris, Digital Interactions in Developing Countries, 2015.
[7] R. Heeks and P. Wall, ICT4D 2018: Major Works, 2018.
[8] A. Lin et al., Information Systems Journal, 2015.
[9] R. Heeks, The Platformization of Development, 2019.
[10] M. Hatakka and R. De', The Capability Approach in ICT4D, 2011.
[11] M. Hoque, Real Freedoms and ICT: Evaluating the Role of Technology in Development, 2020.
[12] D. Kleine, ICT and Development: Enhancing its Role, 2010.
[13] G. Ranis and W. Zhao, Wellbeing and Growth: Towards a New Paradigm in ICT4D, 2013.
[14] A. Fernandez-Baldor et al., ICT4D: New Avenues for Empowerment, 2014.

Background: Capability Approach & Equitable Access

- **Capability Approach (CA)** [4]
  - Reframes development as tool to expand freedoms such as governance, education, healthcare, and social safety
  - “Functionings” (achievable states of being)
  - “Capabilities” (ability to achieve these states)
  - “Choice” (freedom to tap into capabilities)
  - “Conversion factors” (personal, social, environmental conditions affecting choice)
- **CA for ICT4D** [15]-[21]
  - Higher access to ICTs correlates with better outcomes in critical areas of human development (health, education, employment, wellbeing, civic engagement, etc.)
  - Encourages assessing ICT adoption by its impact on expanding people’s freedoms, rather than mere availability
  - Digital literacy critial to enriching use

[15] Y. Zheng and B.C. Stahl, "Technology, Capabilities and Critical Perspectives: What Can Critical Theory Contribute to Sen’s Capability Approach?" Ethics and Information Technology, 2011.
[16] G. Walsham, "Understanding ICT and Development in the Context of Late Development," Information Technology for Development, 2001.
[17] K. Salemink et al., "ICT Inequities: A Systematic Review," Journal of Information Technology, 2015.
[18] L. Denzer et al., "Digital Divide and Outcomes in Health," Health Informatics Journal, 2021.
[19] I. Graetz et al., "Educational Disparities in the Digital Age," Educational Researcher, 2016.
[20] K. Hampton et al., "Employment Opportunities and the Internet," Journal of Labor Economics, 2021.
[21] M. Handley et al., "Wellbeing and Internet Access," Social Indicators Research, 2013.

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To illustrate the capability approach in the context of ICT4D:

accessing information through the internet (functioning) is enabled by digital literacy **skills** (capability) and the **freedom** to use search engines without government censorship (choice), but is dependent on having reliable **internet speeds** (conversion factor).

[15] Y. Zheng and B.C. Stahl, "Technology, Capabilities and Critical Perspectives: What Can Critical Theory Contribute to Sen's Capability Approach?" Ethics and Information Technology, 2011.
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Research Question

How do various markers of choice influence internet use?

- What is the relationship between internet use and **equality**?
- What is the relationship between internet use and **educational attainment**?
- What is the relationship between internet use and **economic conditions**?
- What is the relationship between internet use and markers of **health**?
- What is the relationship between internet use and **governance**?
- What **combination of markers** offers the most **explanatory power** for variation in internet use globally?

Data Selection

- Dependent Variable:
  - Individuals using the Internet (% of population) **"Internet Use"**
  - Adheres to CA emphasis on individual-level analysis

- Independent Variables:
  - Developed **"markers of choice"** from CA literature
  - Markers: Equality, Education, Economics, Health, Governance
    - Represented by **two proxy variables** based on availability and alignment

- From **Global Data Banks**
  - UNESCO, UN Population Division, Human Development Index, ITU, WHO, World Bank Group
  - Latest data ranging from **2020 to 2023** for **104 countries**

Markers of Choice	Proxy Variable	Data Source
Equality	"Female Schooling" School enrollment, secondary, female (% gross)	UNESCO Institute for Statistics (2021)
	"Urban Population" Urban population (% of total population)	United Nations Population Division (2022)
Education	"Secondary Education" School enrollment, secondary (% gross)	UNESCO Institute for Statistics (2021)
	"Mean Years Schooling" Mean years of schooling (years)	HDI, United Nations Human Development Programme (2022)
Economics	"ICT Price Basket" ICT price basket (2017 PPP $)	ITU World Telecommunication/ICT Indicators Database (2023)
	"GNI (PPP)" Gross national income per capita (2017 PPP $)	HDI, United Nations Human Development Programme (2022)
Health	"Life Expectancy" Life expectancy at birth (years)	HDI, United Nations Human Development Programme (2022)
	"Maternal Mortality" Maternal mortality ratio (modeled estimate, per 100,000 live births)	WHO, Trends in Maternal Mortality 2000 to 2020 (2020)
Governance	"Political Stability" Political Stability and Absence of Violence/Terrorism (percentile rank)	World Bank Policy Research Working Paper No. 5430, The Worldwide Governance Indicators (2021)
	"Regulatory Quality" Regulatory Quality (percentile rank)	World Bank Policy Research Working Paper No. 5430, The Worldwide Governance Indicators (2022)

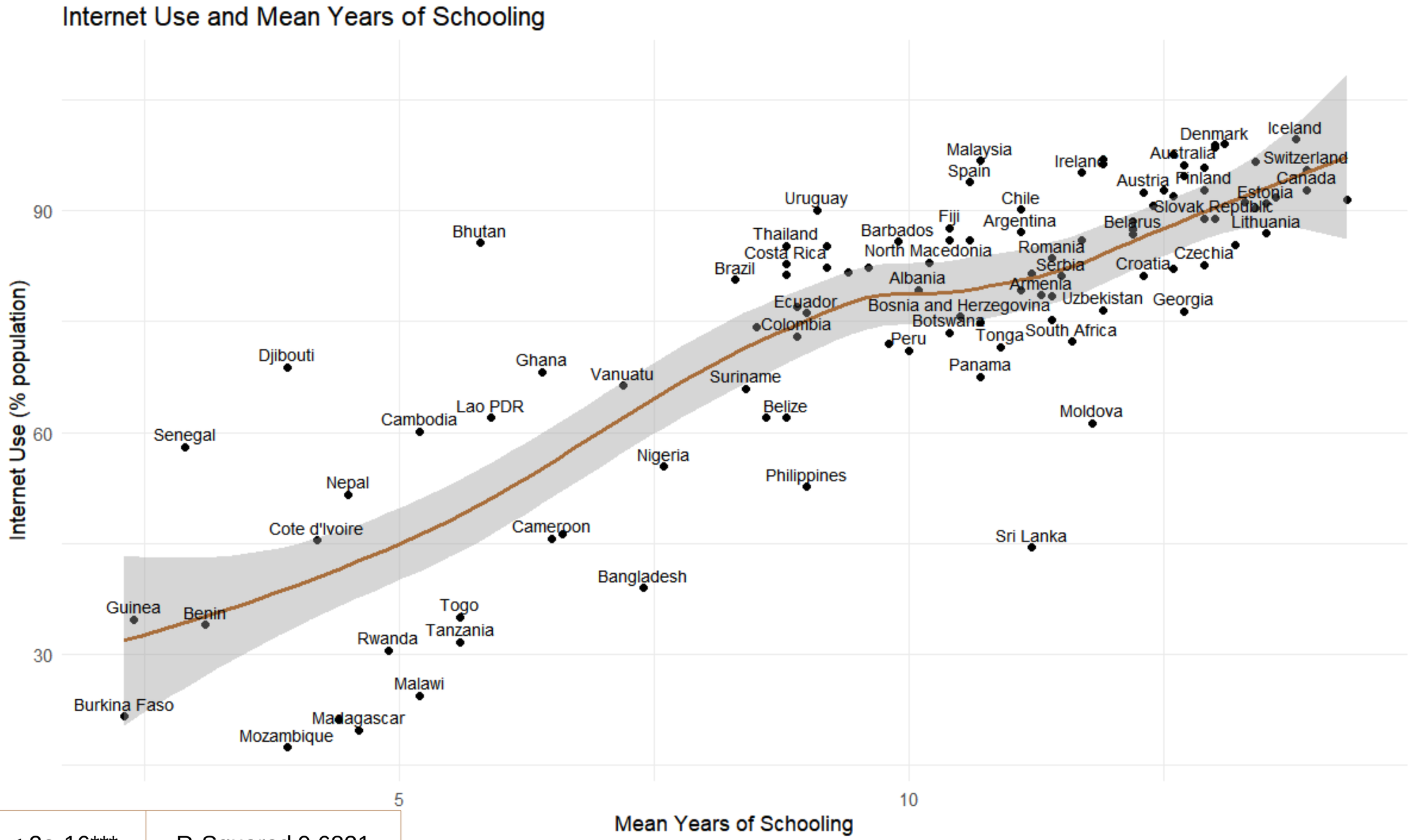
Analytical Protocol

- **Step 1**
  - Simple regression to identify individual relationships
- **Step 2**
  - Multiple regression to investigate multifaceted relationships (education & economics)
- **Step 3**
  - AIC/BIC stepwise regression for best model fit (AIC best fit)

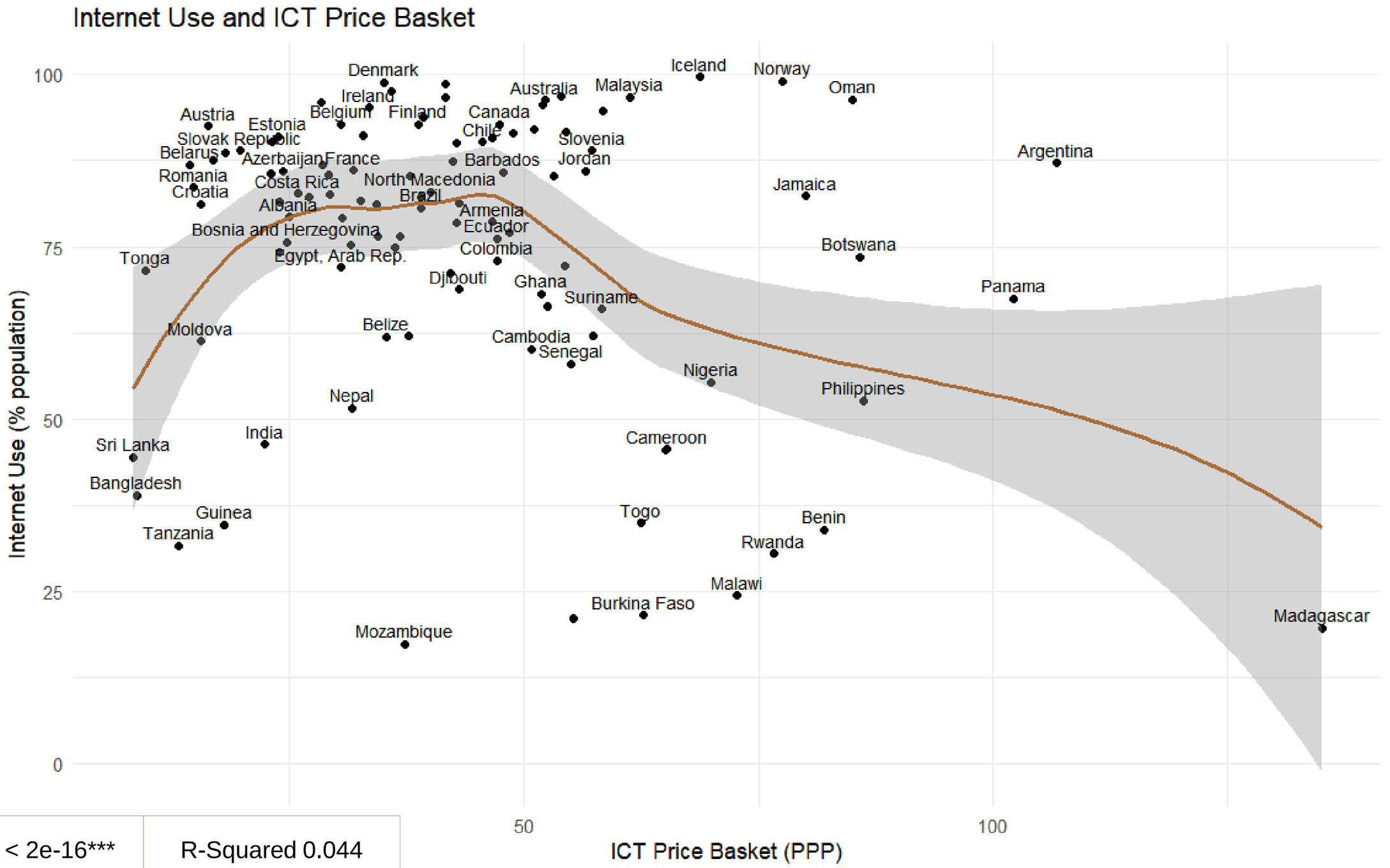
Simple Regression

- All variables significant ($p < 0.05$)
- Education variables have highest R-squared values
- Each education variable explains over 60% of the variation in internet use (R-squared ~ 0.63-0.68)
- Proxy variable for cost of ICTs explains about 4% of the variation in use

Variable	P-Value	R-squared
Mean Years Schooling	< 2e-16***	0.6831
Secondary Education	< 2e-16***	0.652
Female Schooling	< 2e-16***	0.6257
Life Expectancy	< 2e-16***	0.5998
Urban Population	0.0326*	0.5367
Regulatory Quality	< 2e-16***	0.5277
GNI (PPP)	< 2e-16***	0.5024
Maternal Mortality	1.33e-14***	0.4426
Political Stability	1.86e-12***	0.3866
ICT Price Basket	< 2e-16***	0.044



P-Value < 2e-16***	R-Squared 0.6831



P-Value < 2e-16***	R-Squared 0.044

Multiple Regression Model 1
Most Significant Markers

- Model explains about 76% variation in internet use
- Education variables remain the most powerful predictors
- Economic variables (GNI) show weaker significance
- Political Stability and Regulatory Quality are less predictive compared to education

Variable	Coefficient (Est.)	Standard Error	P-Value
Female Schooling	0.2179	0.06556	0.00125**
Mean Years Schooling	2.830	0.5958	6.95e-06***
GNI (PPP)	0.00003117	0.0001031	0.76301
Life Expectancy	0.4445	0.3002	0.14187
Regulatory Quality	0.06046	0.08025	0.45301

Multiple R-squared: 0.7651, Adjusted R-squared: 0.7531

Multiple Regression Model 2
Education Markers

- Model explains about 75% variation in internet use
- Education markers strongly predict internet use
- Both Mean Years of Schooling and Secondary Education remain highly significant

Variable	Coefficient (Est.)	Standard Error	P-Value
Mean Years Schooling	3.41021	0.53446	5.39e-09***
Secondary Education	0.33002	0.06233	6.97e-07***

Multiple R-squared: 0.7519, Adjusted R-squared: 0.747

Multiple Regression Model 3
Economic Markers

- Model explains about 52% variation in internet use
- GNI (PPP) is highly significant ($p < 2e-16$), but its impact is smaller compared to educational variables in other models
- ICT Price Basket shows a weaker, yet still significant negative relationship ($p = 0.0188$), suggesting that higher ICT prices reduce internet usage, but to a lesser degree than expected

Variable	Coefficient (Est.)	Standard Error	P-Value
GNI (PPP)	6.959e-04	6.823e-05	<2e-16***
ICT Price Basket	-1.540e-01	6.451e-02	0.0188*

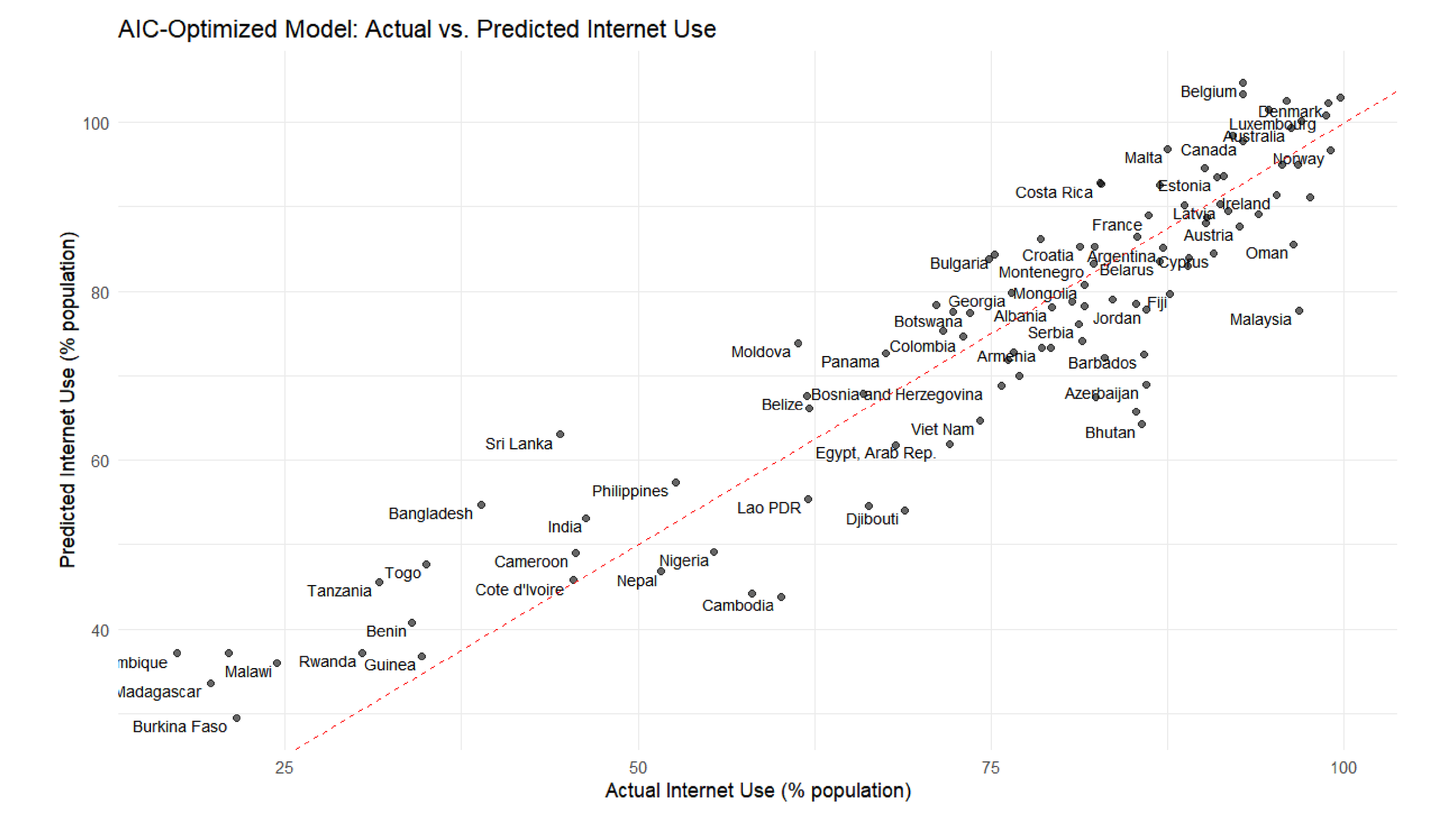
Multiple R-squared: 0.529, Adjusted R-squared: 0.5197

Multiple Regression Model 4 AIC-Optimized Model

- Highest explanatory power; accounting for 83.08% of variation in use
- Urban Population and Mean Years of Schooling are highly significant and contribute most to explaining internet use
- ICT Price Basket shows a weaker negative relationship, indicating a small but notable effect of internet service costs on usage

Variable	Coefficient (Est.)	Standard Error	P-Value
(Intercept)	*11.53860*	4.09683	0.005872**
Urban Population	*0.33123*	0.05861	1.56e-07***
Secondary Education	*0.16804*	0.05769	0.004439**
Mean Years Schooling	*2.24388*	0.48164	1.00e-05***
ICT Price Basket	*-0.08804*	0.04283	0.042503*
Political Stability	*0.16606*	0.04202	0.000147***

AIC: 755.4827, Multiple R-squared: 0.8308, Adjusted R-squared: 0.8222


AIC-Optimized Model: Actual vs. Predicted Internet Use
Predicted Internet Use (% population)
Actual Internet Use (% population)
100
80
60
40
25
50
75
100
Belgium
Denmark
Luxembourg
Australia
Malta
Canada
Norway
Costa Rica
Estonia
Ireland
Latvia
France
Austria
Croatia
Argentina
Oman
Bulgaria
Cyprus
Montenegro
Belarus
Mongolia
Georgia
Fiji
Albania
Jordan
Malaysia
Botswana
Serbia
Moldova
Colombia
Armenia
Panama
Barbados
Azerbaijan
Bosnia and Herzegovina
Belize
Viet Nam
Bhutan
Egypt, Arab Rep.
Sri Lanka
Philippines
Lao PDR
Djibouti
Bangladesh
India
Cameroon
Nigeria
Togo
Nepal
Tanzania
Cote d'Ivoire
Cambodia
Benin
Rwanda
Guinea
Malawi
Madagascar
Burkina Faso

Implications

Digital Skills > Cutting Costs

Educational attainment, especially mean years of schooling, has a greater impact on internet use than income or affordability. Focus should shift to improving education and digital literacy to expand access.

Holistic ICT4D

A comprehensive approach to internet access is essential, incorporating educational, economic, and governance variables. The findings suggest that political stability plays a crucial role in infrastructure deployment and effective internet use.

Capability Approach Lens

Expanding freedoms such as education or political stability contributes to broader development goals. The capability approach offers a robust framework for understanding how freedoms interact to enhance internet access and, by extension, development.

Future Directions

Digital Literacy Data

Proxies for *digital* literacy are difficult to find at scale. OECD countries have already started collecting such data, which could be leveraged to understand how digital skills influence internet use and development outcomes.

Longitudinal Data

Longitudinal studies are needed to track changes in internet use over time. Analyzing pre- and post-COVID data would offer insights into how access and usage evolved under pressure and point to successful programs and policies for expanding enriching access.

Machine Learning Models

Machine learning models can provide a more nuanced understanding of internet use patterns, potentially with predictive power for national "tipping points" for equitable and enriching access.

Thank you!

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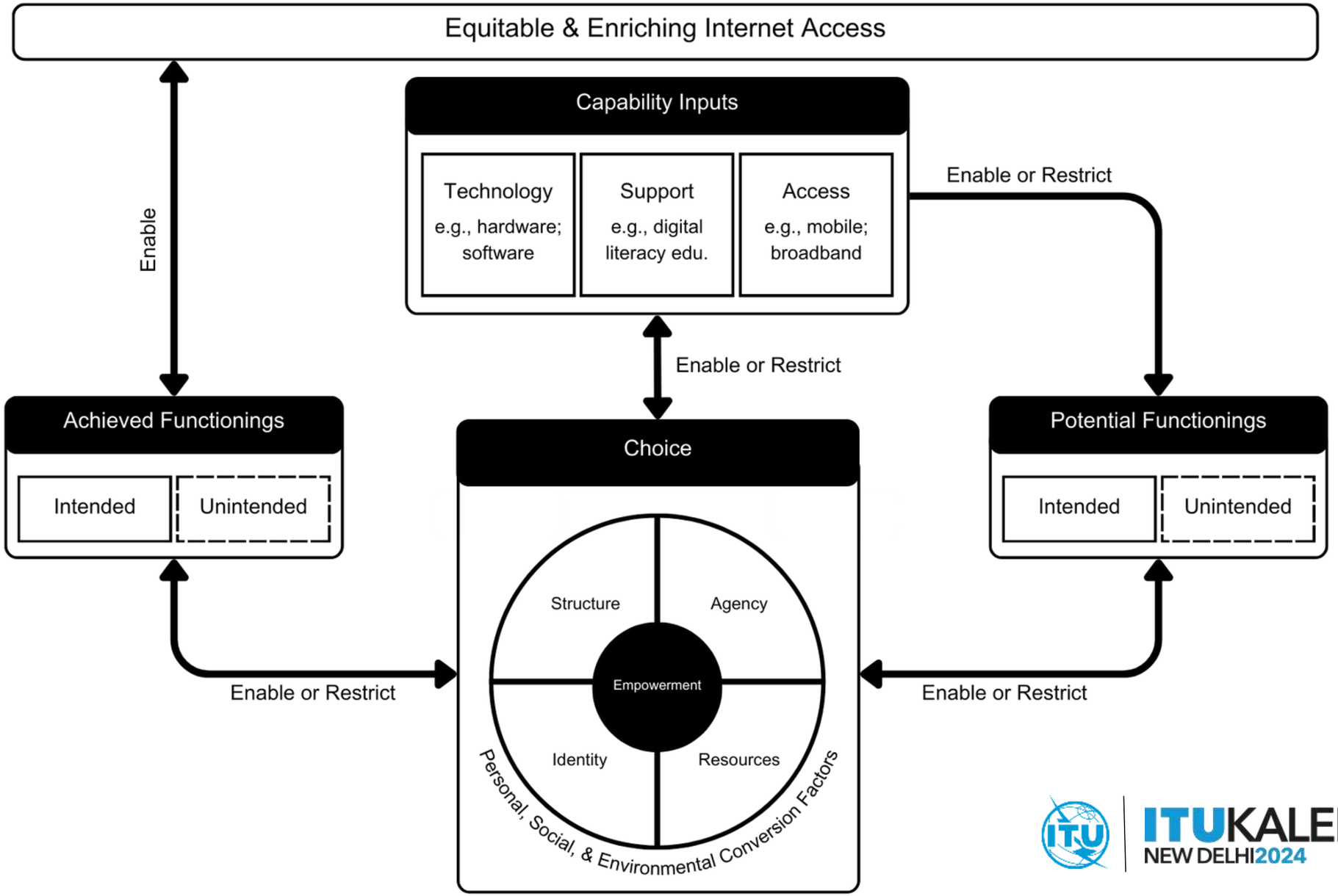
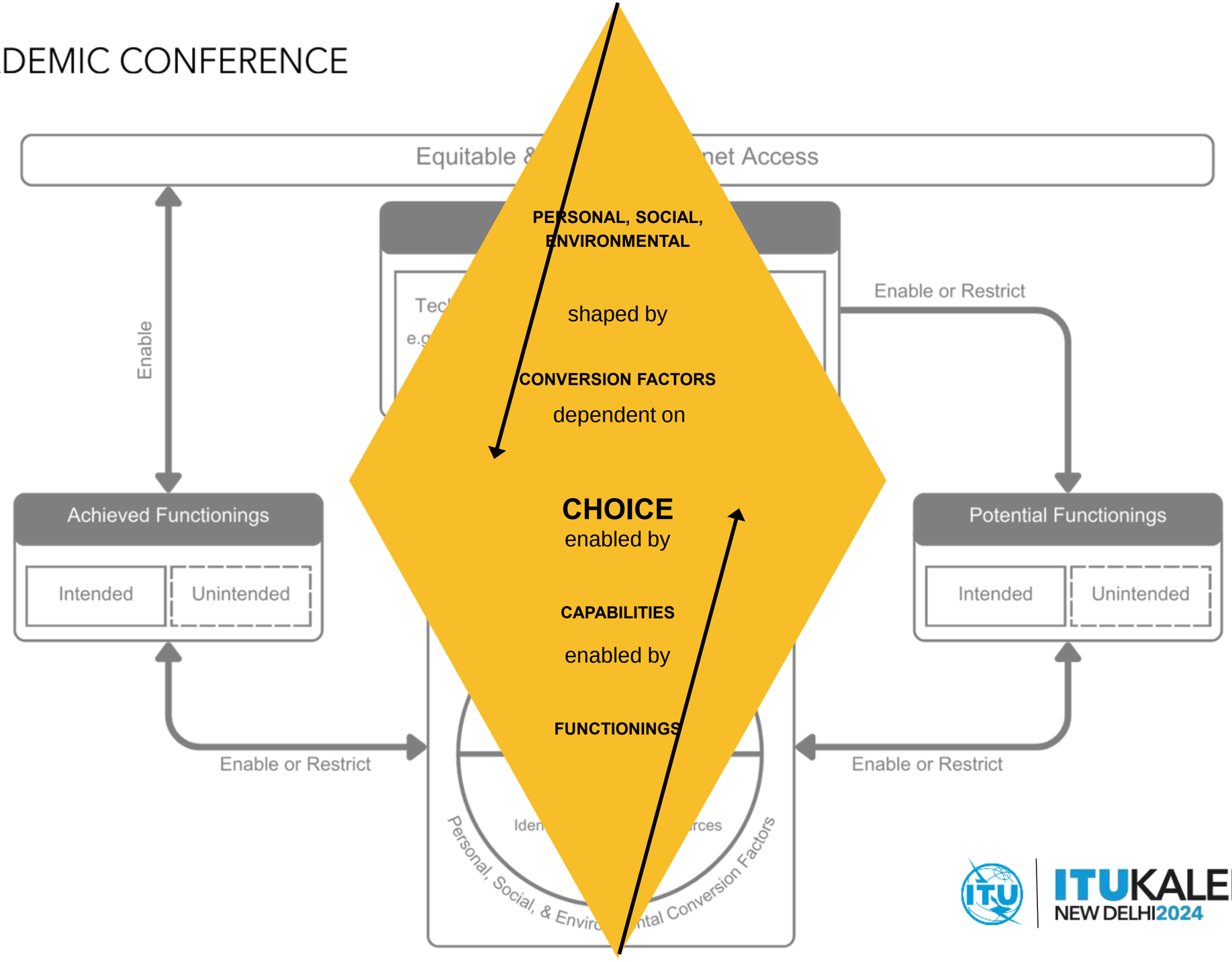
"...it is not the technology in itself that is enabling; it is the **features within** the technology and the **use of them**."

— Mathias Hatakka & Rahul De'


Equitable & Enriching Internet Access
Enable
Capability Inputs
Technology
e.g., hardware; software
Support
e.g., digital literacy edu.
Access
e.g., mobile; broadband
Enable or Restrict
Enable or Restrict
Achieved Functionings
Intended
Unintended
Choice
Potential Functionings
Intended
Unintended
Structure
Agency
Empowerment
Identity
Resources
Personal, Social, & Environmental Conversion Factors
Enable or Restrict
Enable or Restrict


Equitable &
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PERSONAL, SOCIAL, ENVIRONMENTAL
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