UOC IN3 Internet Interdisciplinary Institute

Measuring digital development for policy-making: Models, stages, characteristics and causes

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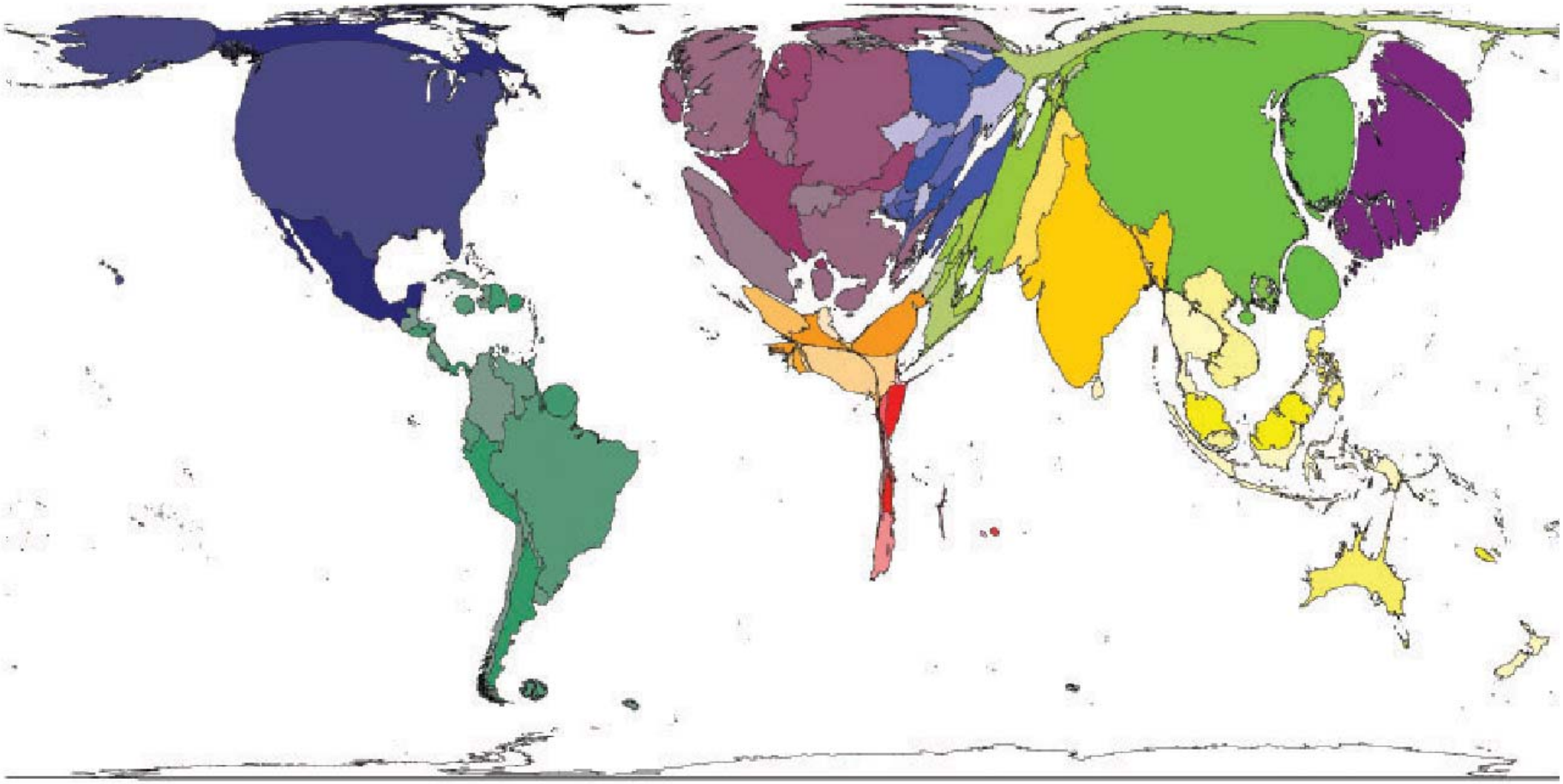
Universitat Oberta de Catalunya

PhD Thesis Defence
Barcelona, September 8th, 2009

So...



Internet Users Year 2007

Data from International Telecommunication Union

www.worldmapper.org

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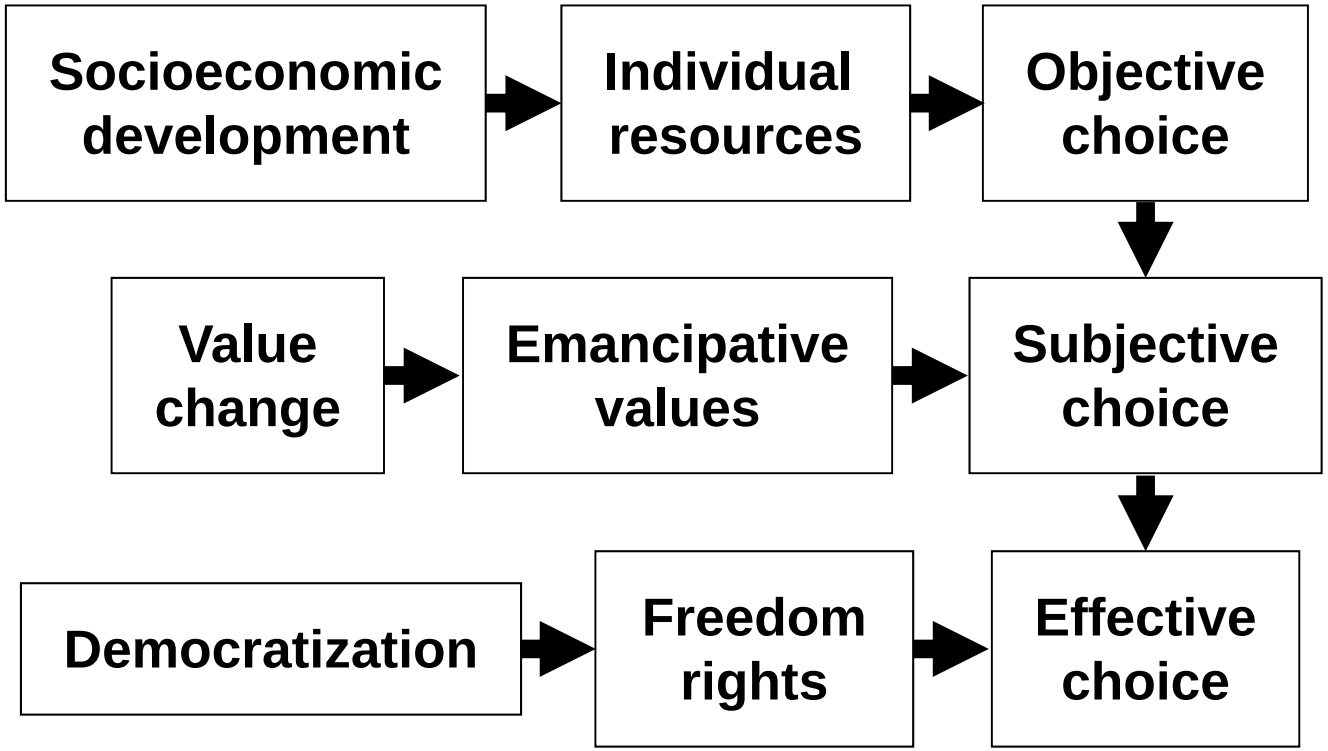
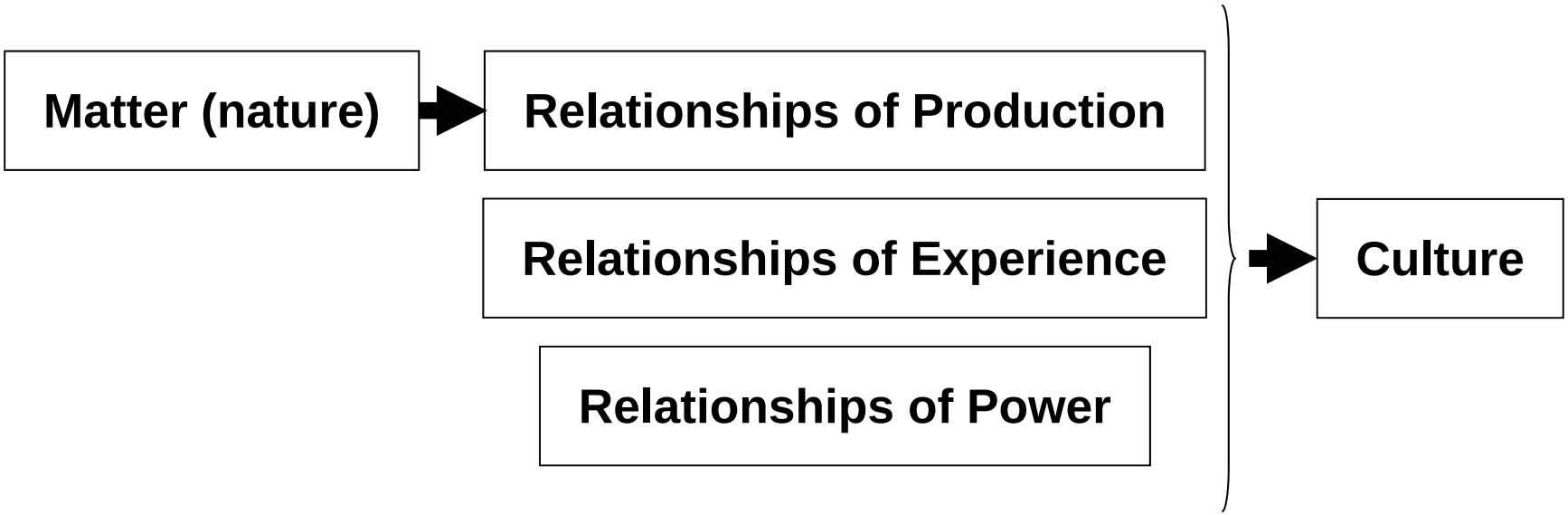
Why this research

Components of human development



Adapted from Welzel et al. (2003)

Social structures (& Network Society)



Adapted from Castells, M. (2000)

The Digital Economy as an enabler

Development	The Digital Economy	Network Society
Socioeconomic Development (individual resources)	INFRASTRUCTURES	Matter (nature)
	ICT SECTOR	Production
Value Change (emancipative values)	(DIGITAL) LITERACY	Experience
Democratization (freedom rights)	LEGAL FRAMEWORK	Power
	USES (CONTENT & SERVICES)	Culture

Source: author

Fostering access to the Digital Economy

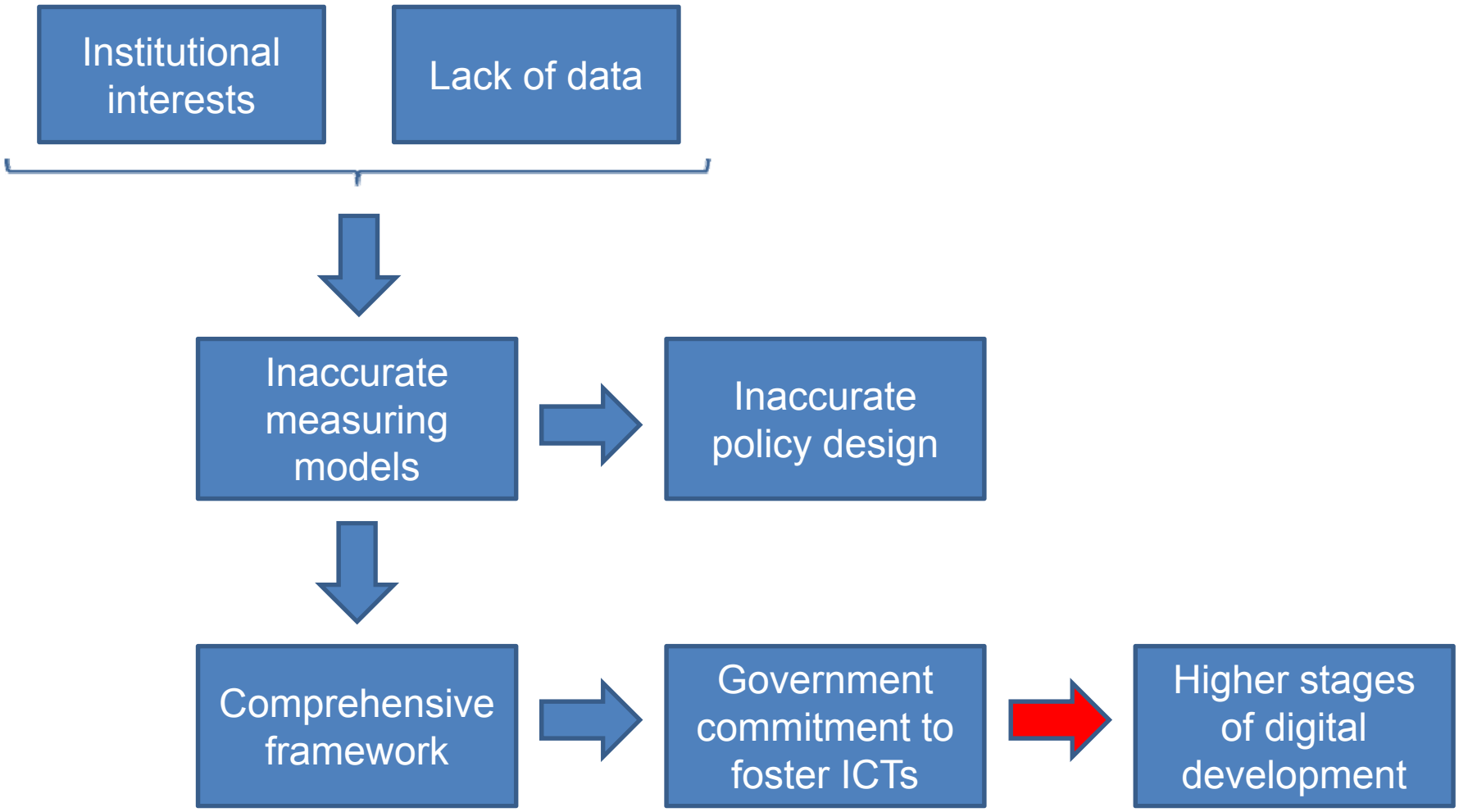
- **A Digital Revolution**: Mokyr (1997, 2000), Greenwood (1999), Boas et al. (2005), Zysman, J. & Newman (2006)

- **The Concept of Access**: Raboy (1995, 1998), ITU (1998-2009), WEF (2002-2009), Sciadas (2003), Gillwald and Stork (2007)

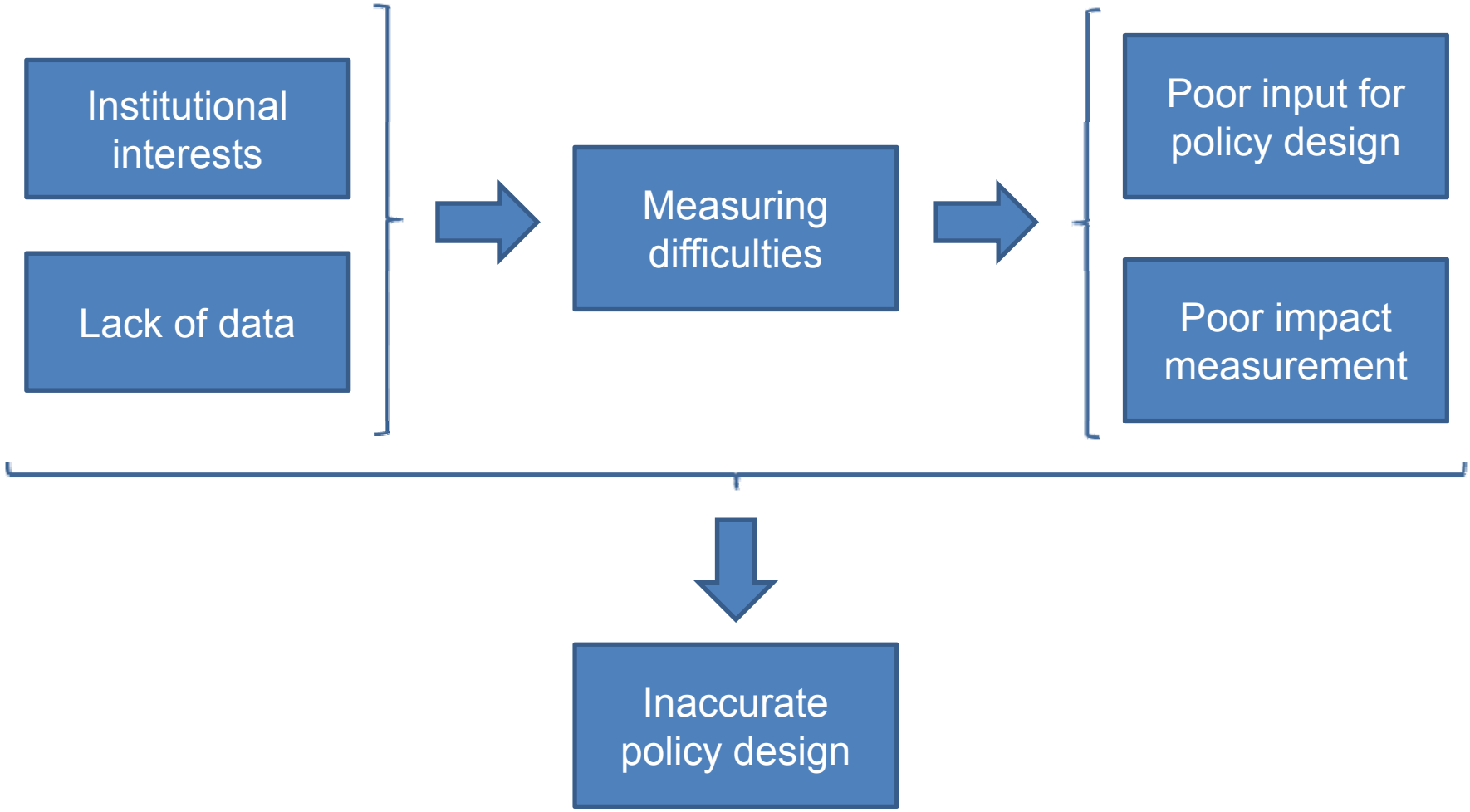
- **The Digital Divide**: NTIA (1999), Hargittai (2001), Bridges.org (2001), Warschauer (2003), Gunkel (2003), DiMaggio et al. (2004), Barzilai-Nahon (2006), Tibben (2007)

- **Policies of (universal) Access**: Hudson (1994), Albery (1995), Compaine & Weinraub (1997), OECD (2001b), Loader & Keeble (2004), ITU (2005e), Kenny and Keremane (2007)

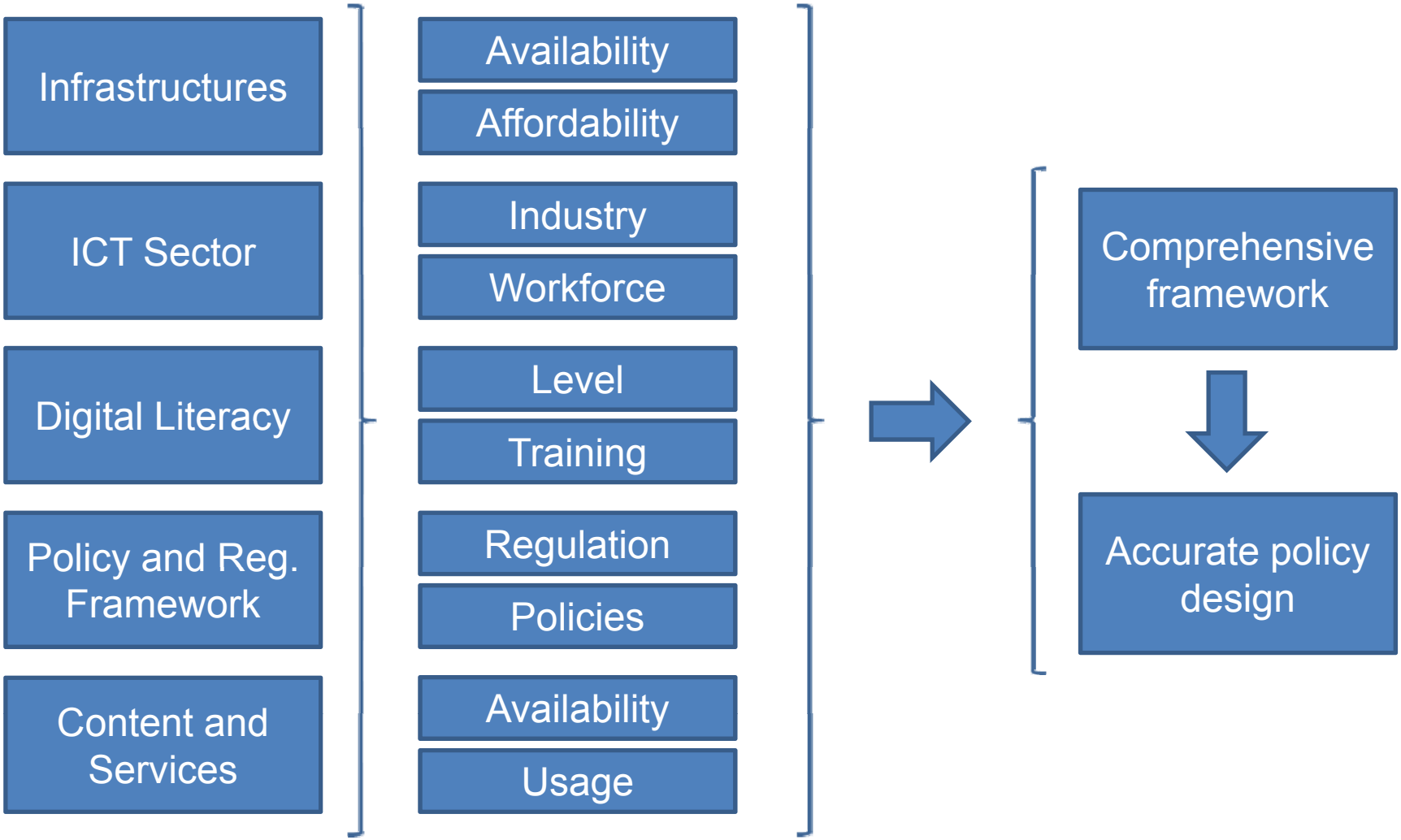
General hypothesis



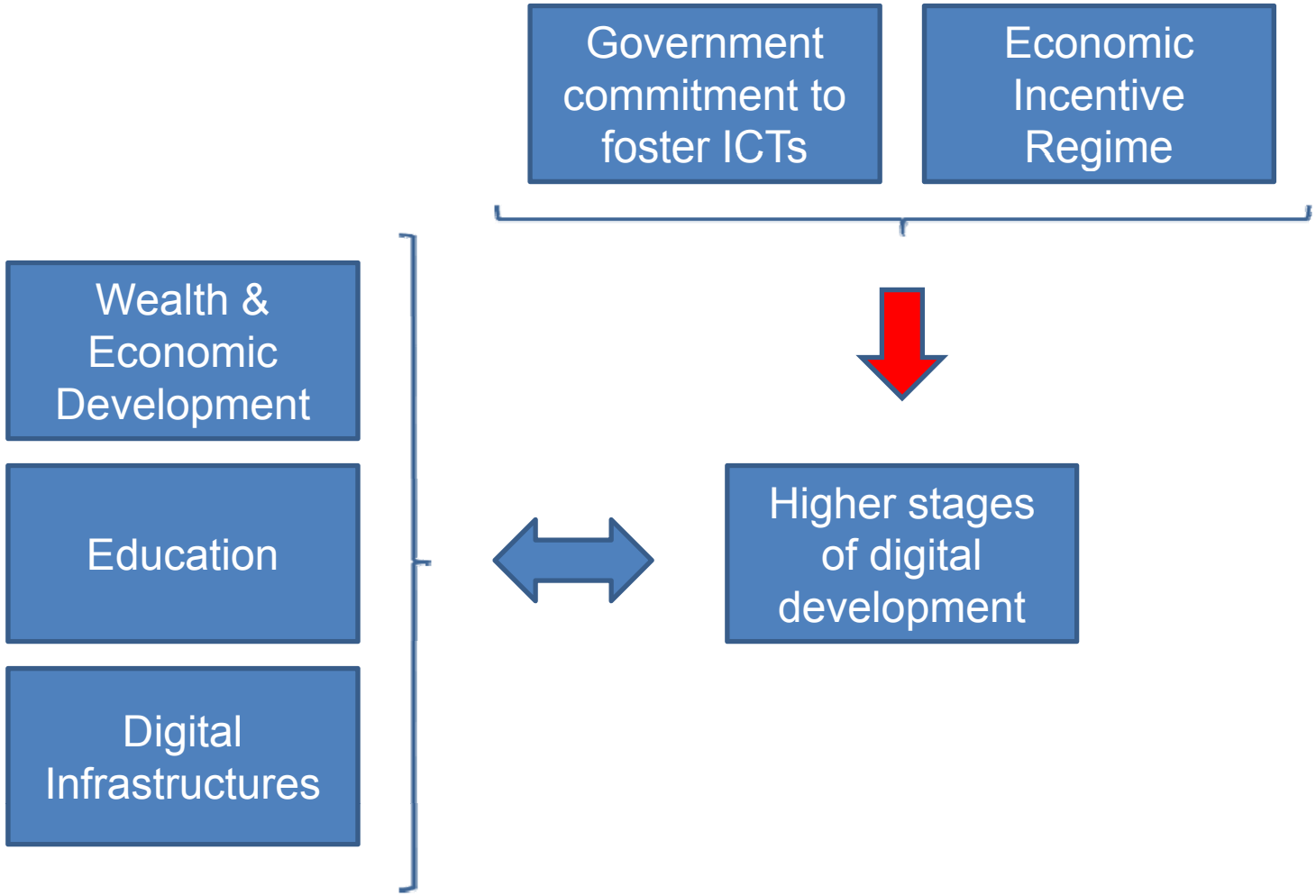
Working hypothesis #1



Working hypothesis #2

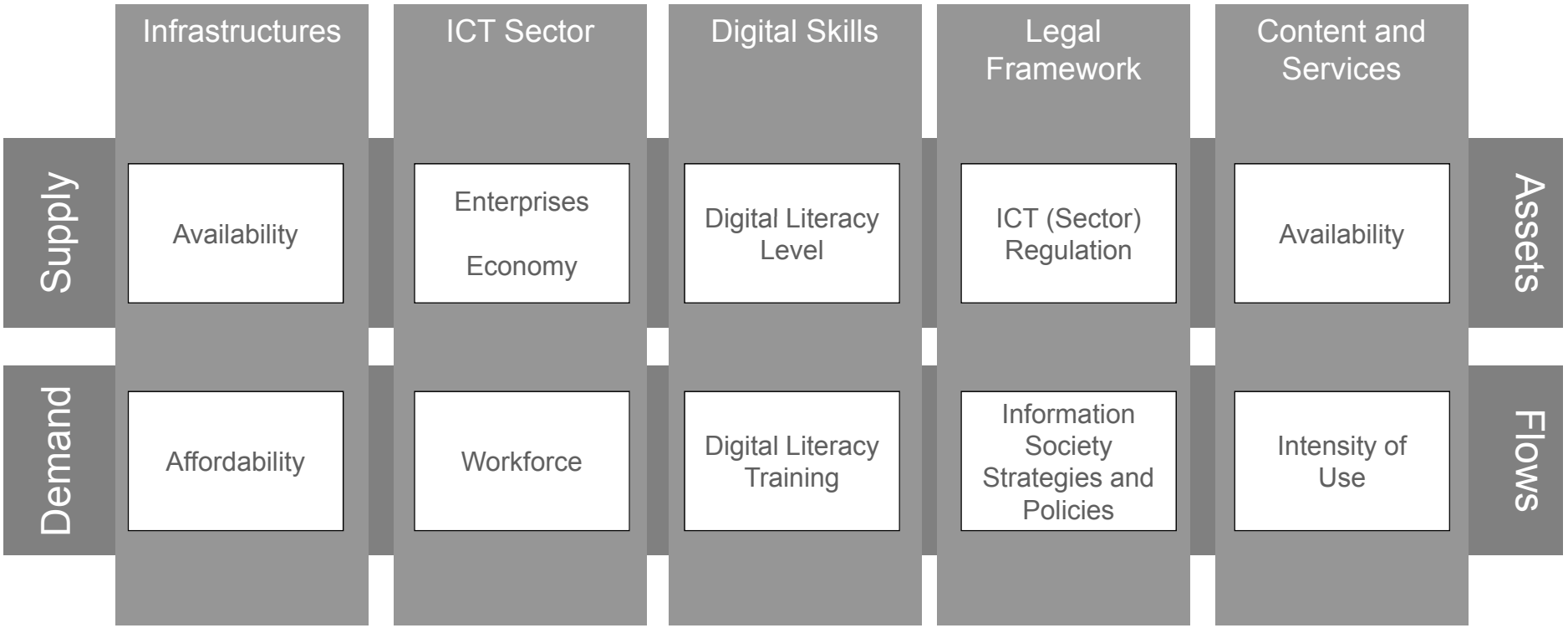


Working hypothesis #3



Methodology

Proposed model: 360º Digital Framework



Source: author

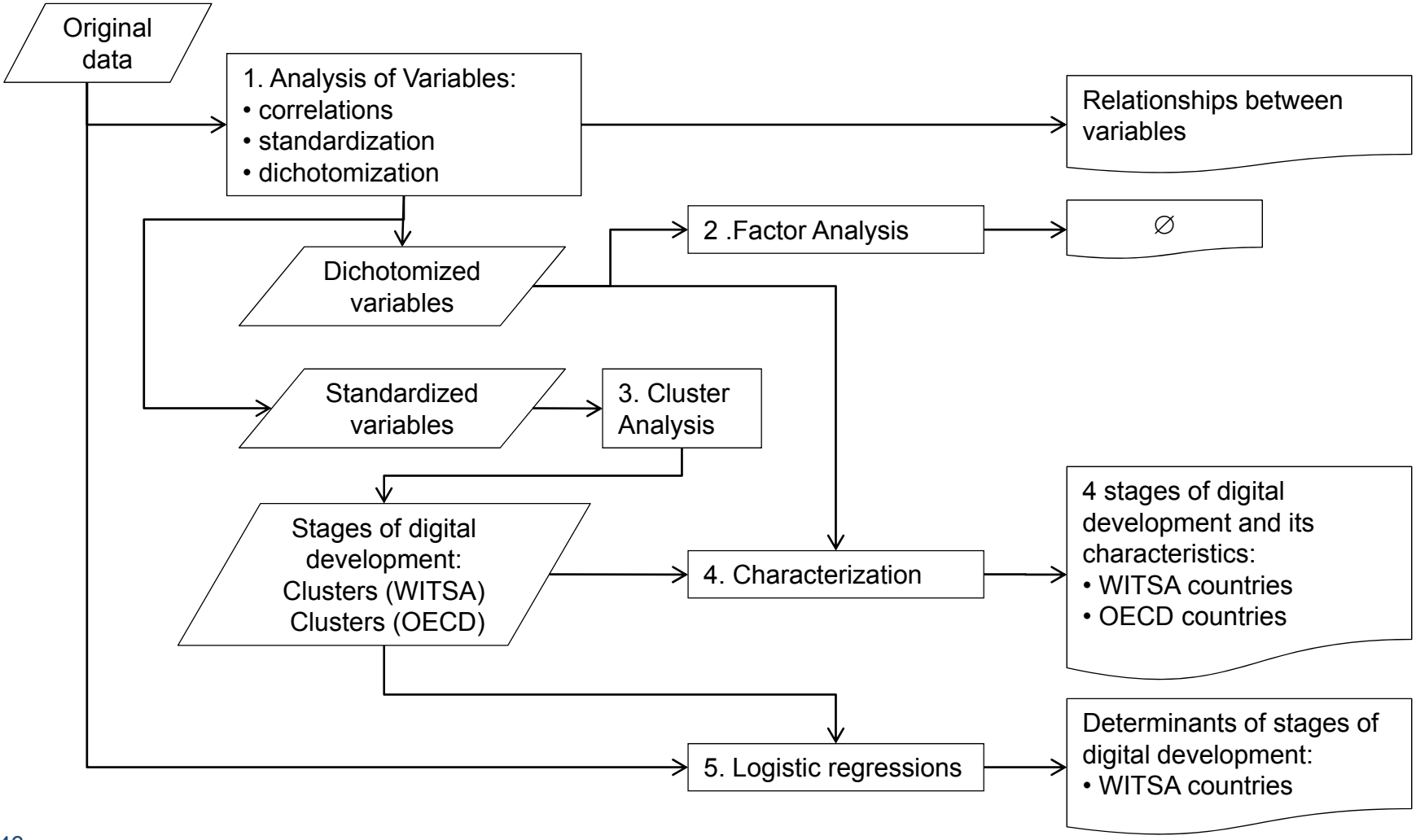
Qualitative analysis

- 55 models of the Digital Economy: descriptive and theoretical models, composite indices, sets of indicators
- Count of different indicators used (1578) and number of time series
- Identification of categories and iterative category reallocation of indicators

For each model:

- Description: who, when, where, why, how
- Main publications
- Distribution of indicators by category
- Fitness of model in 360º Digital Framework
- Critique

Quantitative analysis: statistics



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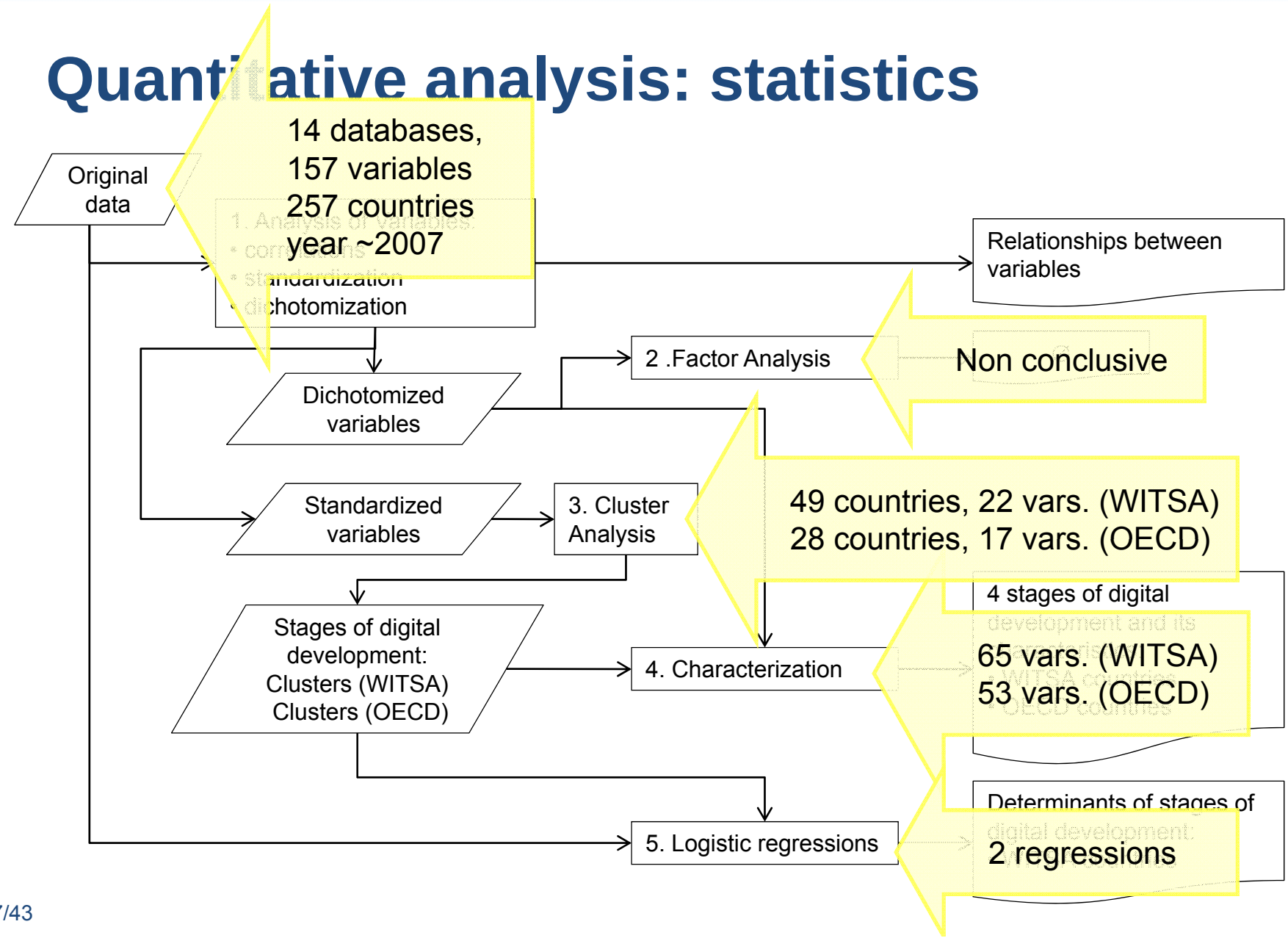


Bridging theory and practice

	Infrastructures	ICT Sector	Digital Skills	Policy and Regulatory Framework	Content and Services
Supply/Assets	6	1	1	2	3
Demand/Flows	1	1	1	1	5

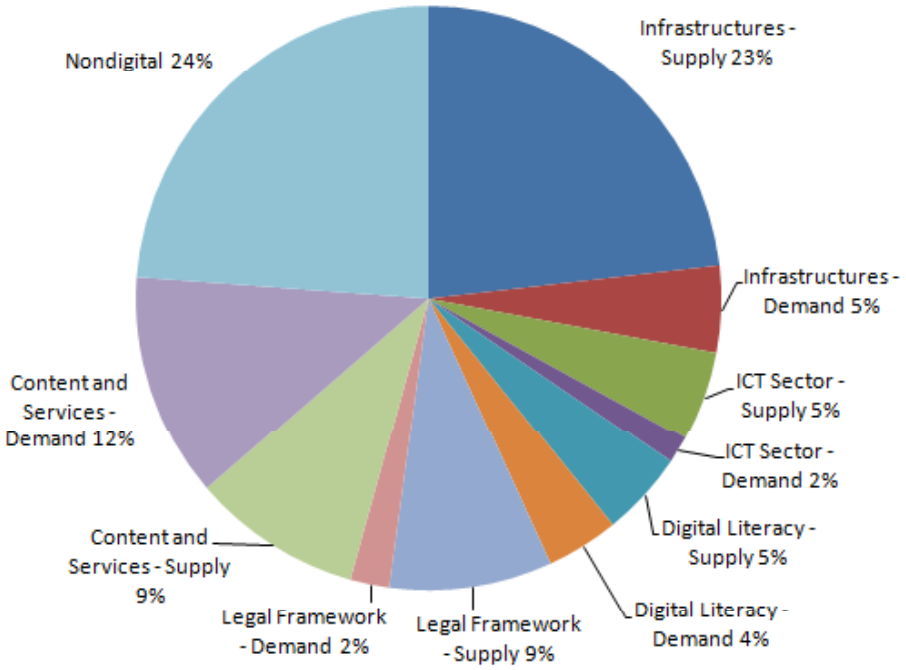
Indicators (then variables) used to build the clusters (WITSA)

	Infrastruct.	ICT Sector	Digital Skills	Policy and Regulatory Framework	Content and Services	Nondigital
Supply/Assets	8	2	2	3	5	27
Demand/Flows	5	4	1	2	6	

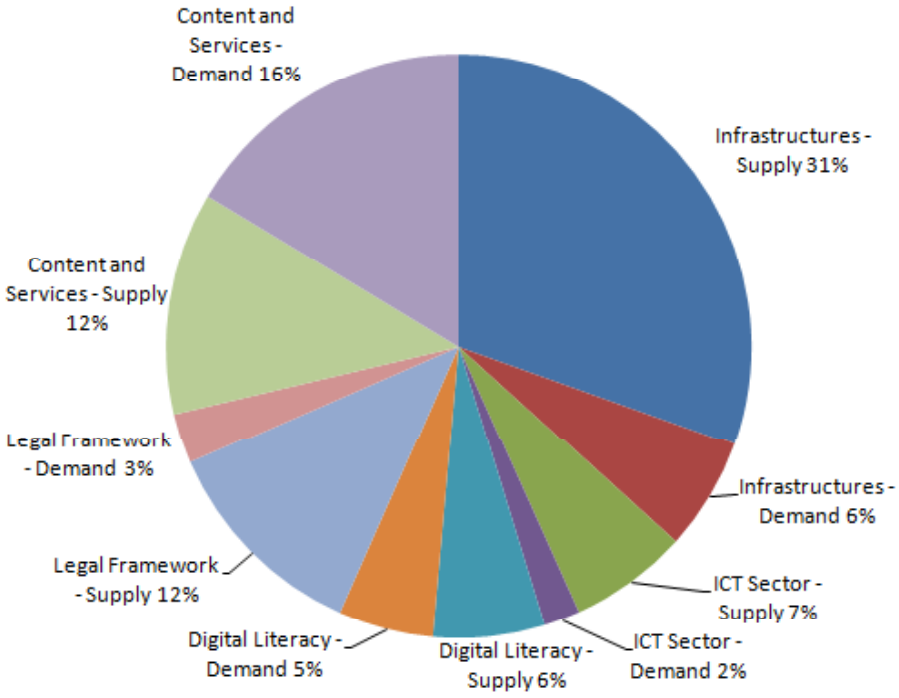
Indicators (vars.) used to characterize the stages of digital development (WITSA)

Results

The state of world indicators and indices (I)



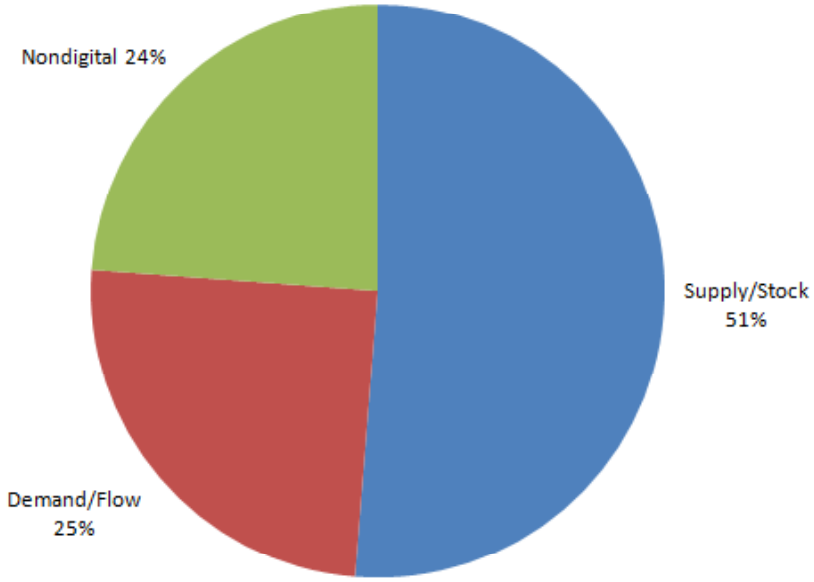
Distribution of the extended aggregate categories – including analogue indicators



Distribution of the extended aggregate categories – excluding analogue indicators

Charts show the number of indicators (%) in all Digital Economy models within each category

The state of world indicators and indices (II)



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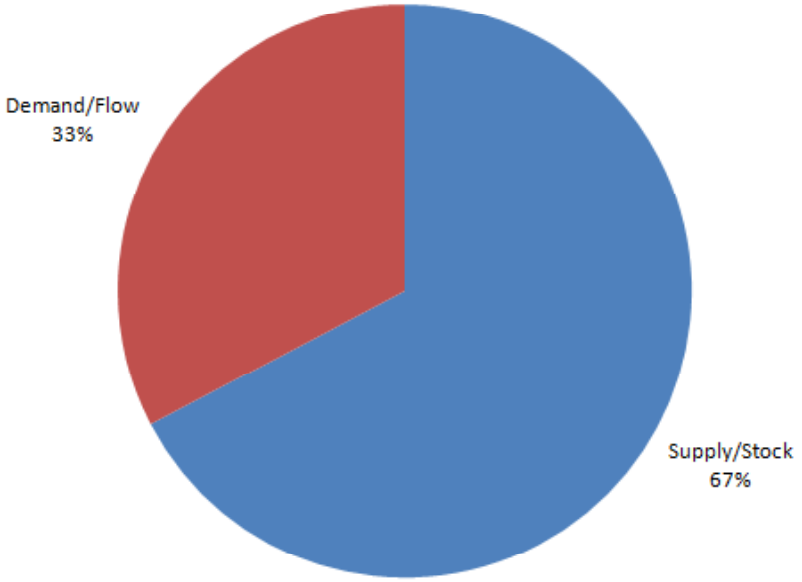

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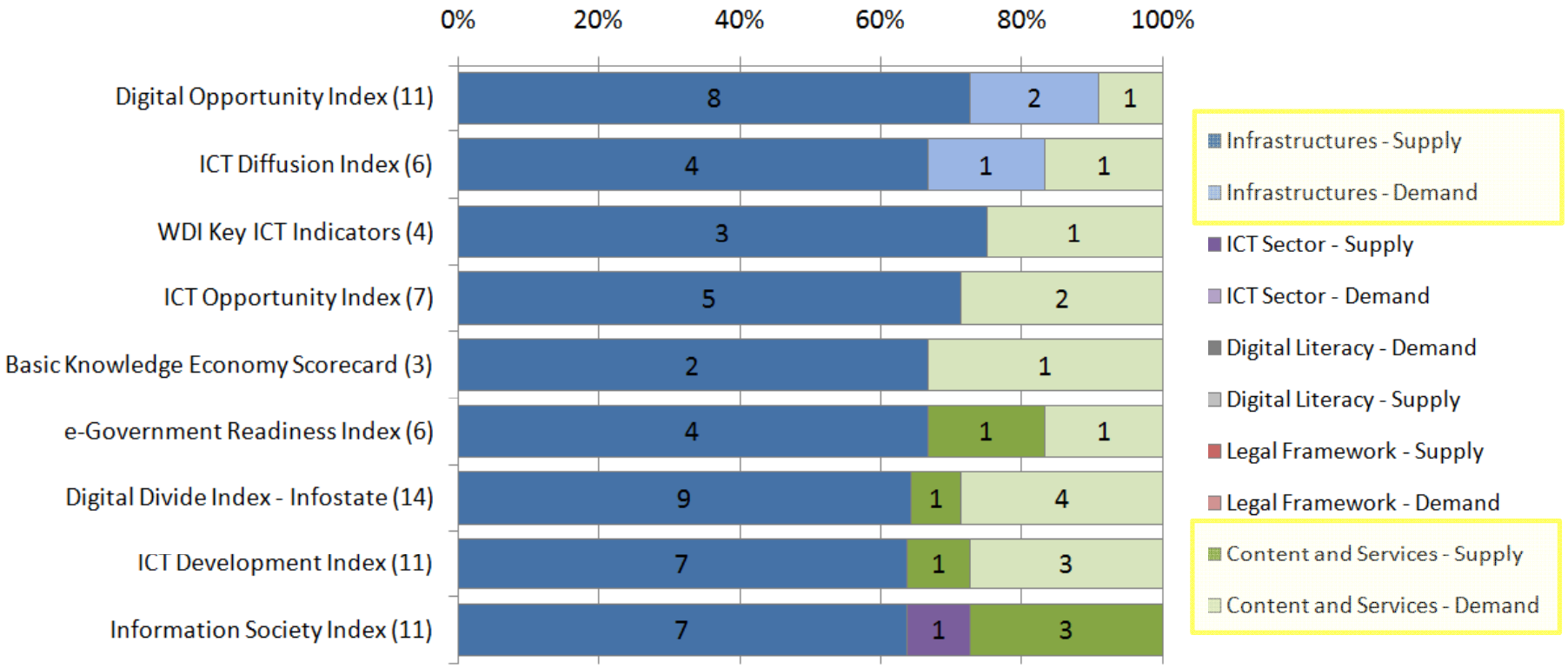
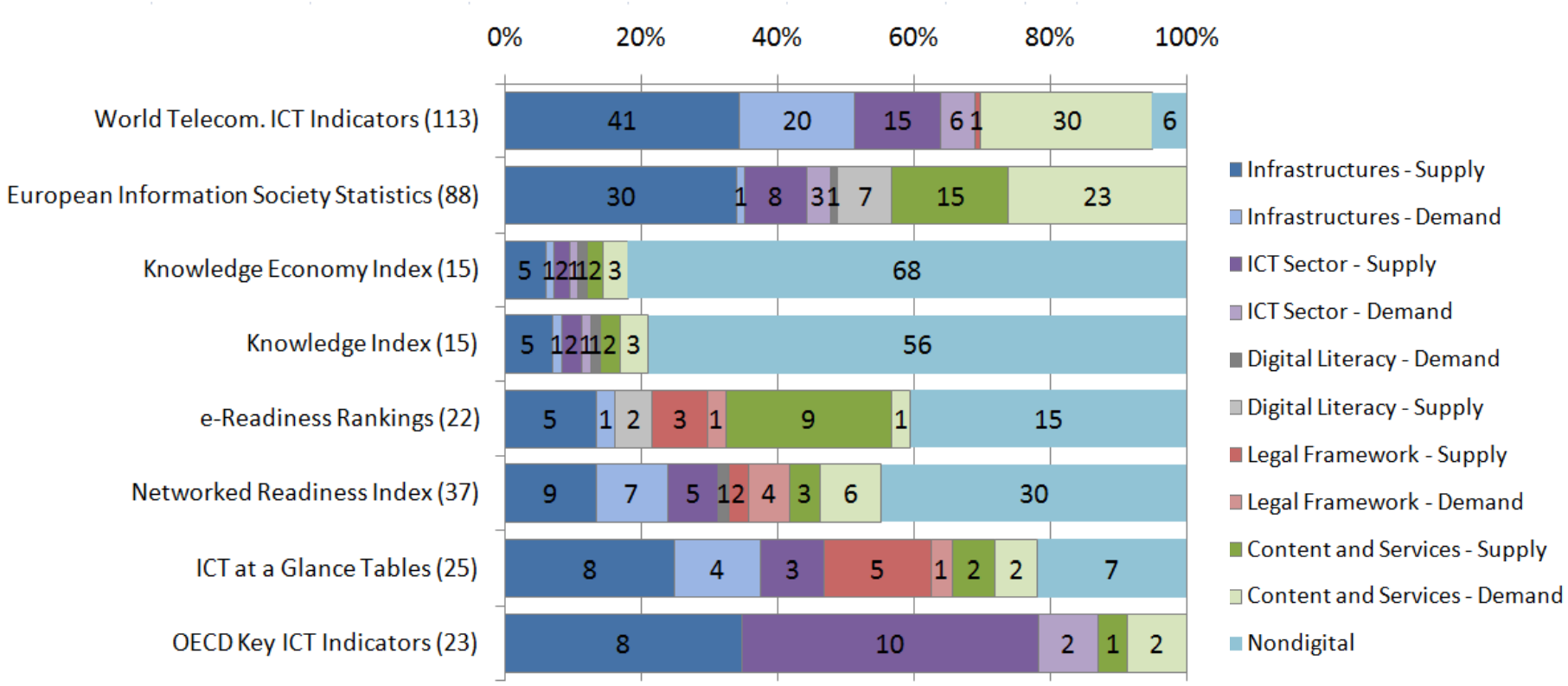
The Telecom Approach



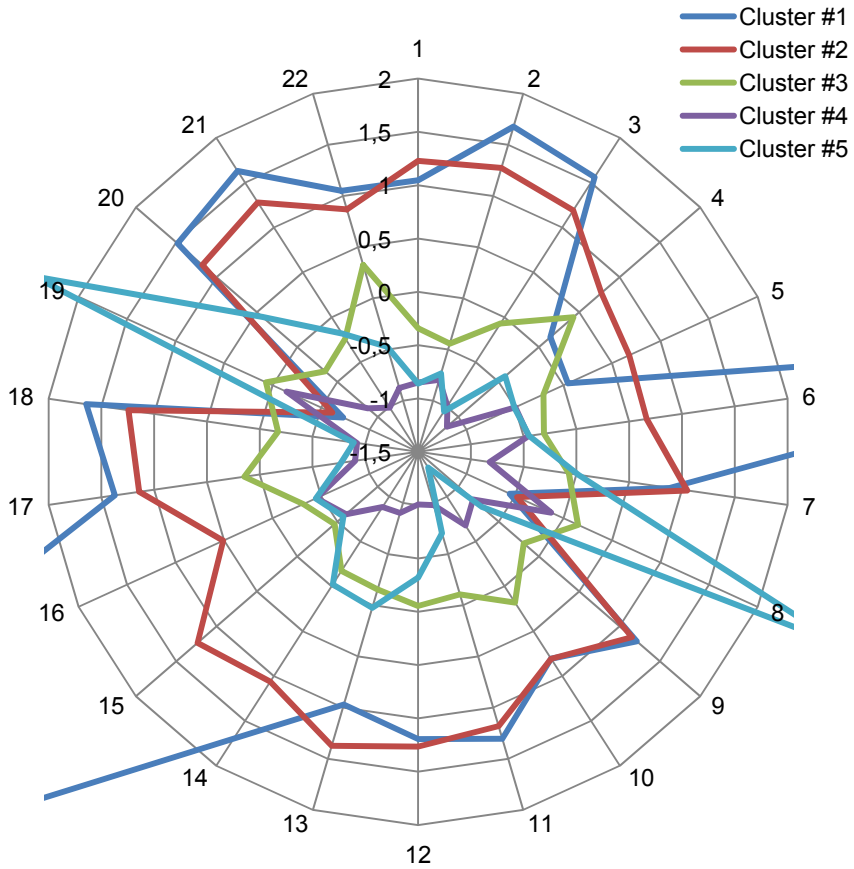
Charts show the number of indicators in selected Digital Economy models within each category

The Broadcasting/e-Readiness approach



Charts show the number of indicators in selected Digital Economy models within each category

Cluster centre values for WITSA countries



Non-hierarchical K-means cluster analysis.
Significance of F in ANOVA for *all* variables: p<0.001

1 - Broadband subscribers (per 100 people)
2 - Personal computers (per 100 people)
3 - Telephone mainlines (per 100 people)
4 - Mobile phone subscribers (per 100 people)
5 - International Internet bandwidth (bits per person)
6 - Internet Hosts (per 10000 people)
7 - Price basket for residential fixed line (US$ per month)
8 - Telecommunications revenue (% GDP)
9 - GDP per Telecom Employee (US Dollars)
10 - Human Capital
11 - Internet Access in Schools
12 - Laws relating to ICT
13 - Intellectual property protection
14 - Gov't procurement of advanced tech products
15 - Secure Internet servers (per 1 million people)
16 - Total Domains (per 100 people)
17 - Availability of government online services
18 - Internet users (per 100 people)
19 - Total ICT Spending, Consumer (% of GDP)
20 - Firm-level technology absorption
21 - Extent of business Internet use
22 - ICT use and government efficiency

Stages of digital development (WITSA)

- **Digital leaders (clusters #1 & #2; n = 1+14)**:

  USA, Australia, Austria, Finland, France, Germany, Ireland, Japan, Rep. of Korea, New Zealand, Norway, Singapore, Sweden, Switzerland, UK

- **Digital strivers (cluster #3; n = 17)**:

  Brazil, Bulgaria, Chile, Greece, Hungary, Italy, Jamaica, Mexico, Panama, Portugal, Romania, Saudi Arabia, Spain, Thailand, Tunisia, Uruguay, United Arab Emirates

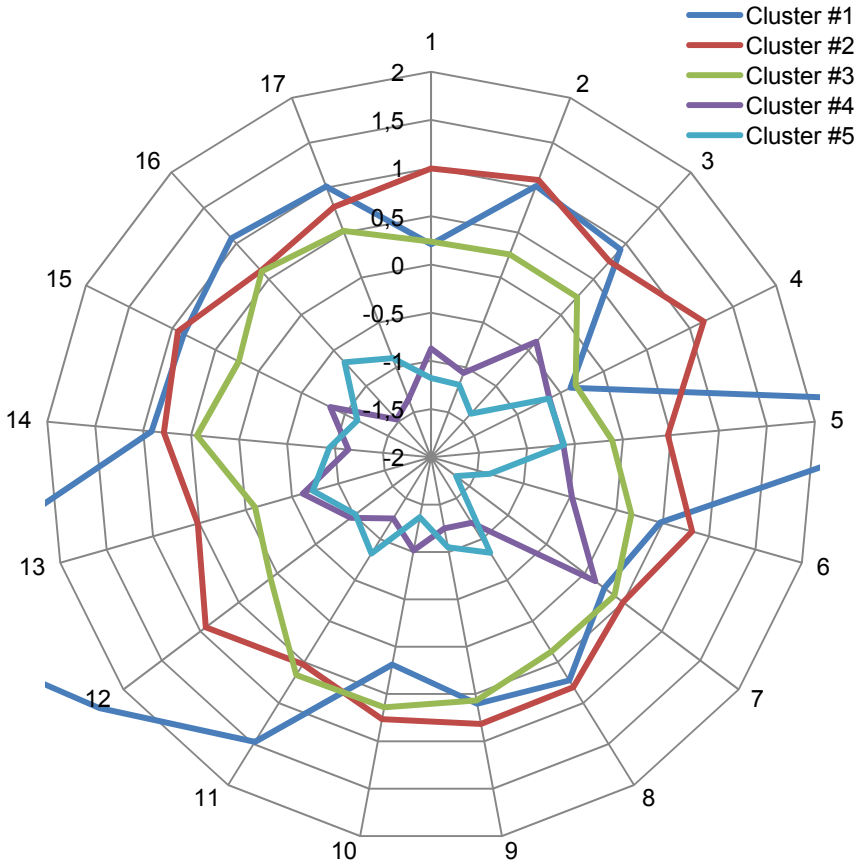
- **Digital laggards (cluster #4; n = 14)**:

  Argentina, Bolivia, Ecuador, Egypt, India, Indonesia, Pakistan, Peru, Philippines, Sri Lanka, Algeria, Cameroon, Vietnam, Zimbabwe

- **Digital leapfroggers (cluster #5; n = 3)**:

  Jordan, South Africa, Senegal

Cluster centre values for OECD countries



1 - Broadband subscribers (per 100 people)
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15 - Internet users (per 100 people)
16 - Firm-level technology absorption
17 - Extent of business Internet use

Non-hierarchical K-means cluster analysis.
Significance of F in ANOVA for *all* variables: $p<0.001$

Stages of digital development (OECD)

- **Primary digital leaders (clusters #1 & #2; n = 1 + 8)**:

  USA, Australia, Canada, Denmark, Netherlands, Norway, Sweden, Switzerland, UK

- **Secondary digital leaders (cluster #3; n = 8)**:

  Austria, Finland, France, Germany, Ireland, Japan, Rep. of Korea, New Zealand

- **Primary digital strivers (cluster #4; n = 5)**:

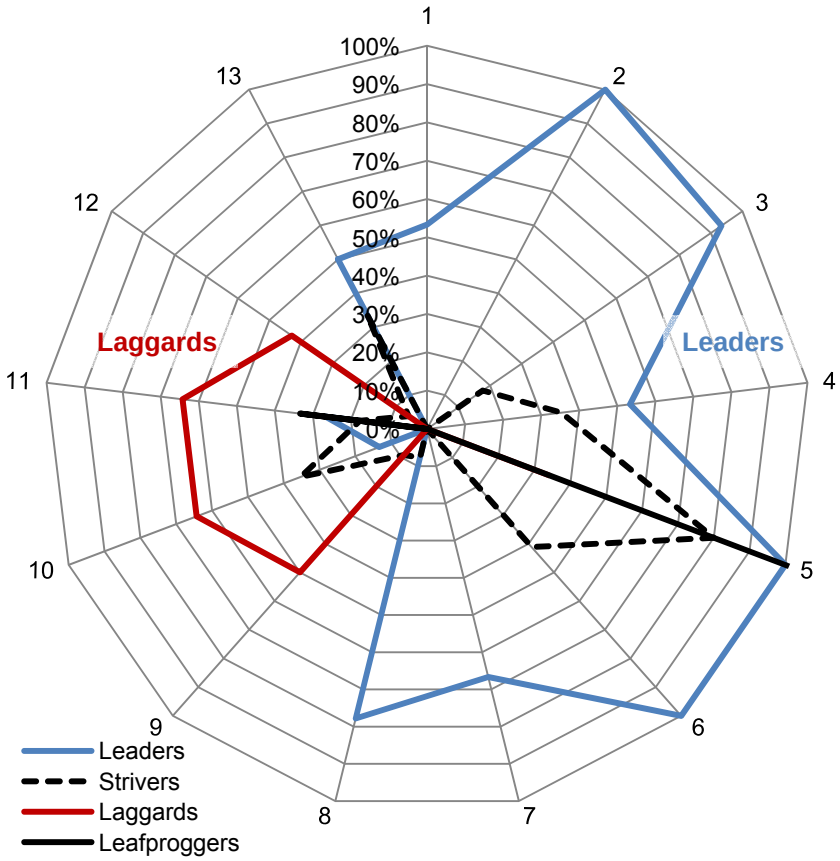
  Greece, Hungary, Italy, Poland, Spain

- **Secondary digital strivers (cluster #5; n = 5)**:

  Czech Republic, Mexico, Portugal, Slovak Republic, Turkey

Results: characterization of stages

Infrastructures



1 - Broadband subscribers (per 100 people) (*)

2 - Personal computers (per 100 people) (*)

3 - Telephone mainlines (per 100 people) (*)

4 - Mobile phone subscribers (per 100 people) (*)

5 - Population covered by mobile telephony (%) (*)

6 - International Internet bandwidth (bits per person) (*)

7 - Internet Hosts (per 10000 people) (*)

8 - Internet subscribers (per 100 inhabitants) (*)

9 - Residential monthly telephone subscription (US$) (**)

10 - Price basket for Internet (US$ per month) (**)

11 - Price basket for mobile (US$ per month) (**)

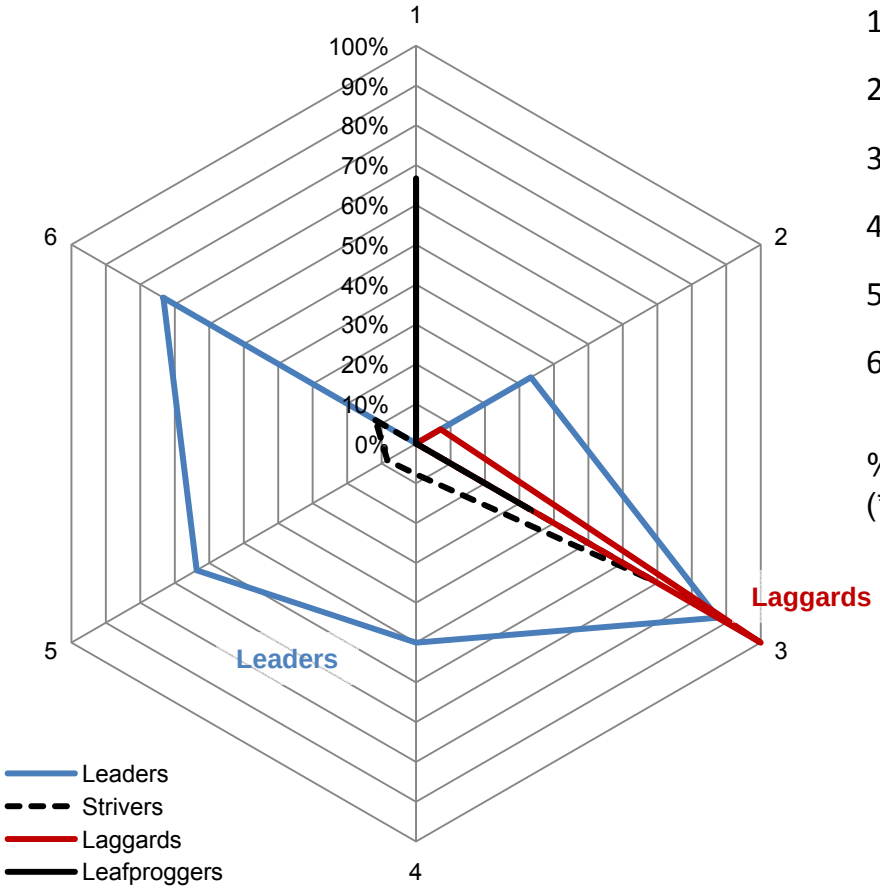
12 - Price basket for residential fixed line (US$ per month) (*)

13 - Telephone average cost of call to US (US$ per three minutes) (***)

% of countries that scored “high” on indicator per cluster
(*): p<0.01 (**): p<0.05 (***): p<0.1

Results: characterization of stages

ICT Sector



1 - Telecommunications revenue (% GDP) (*)

2 - High-technology exports (% of manufactured exports) (**)

3 - Telephone subscribers per employee (***)

4 - Telephone employees (per 100 people) (**)

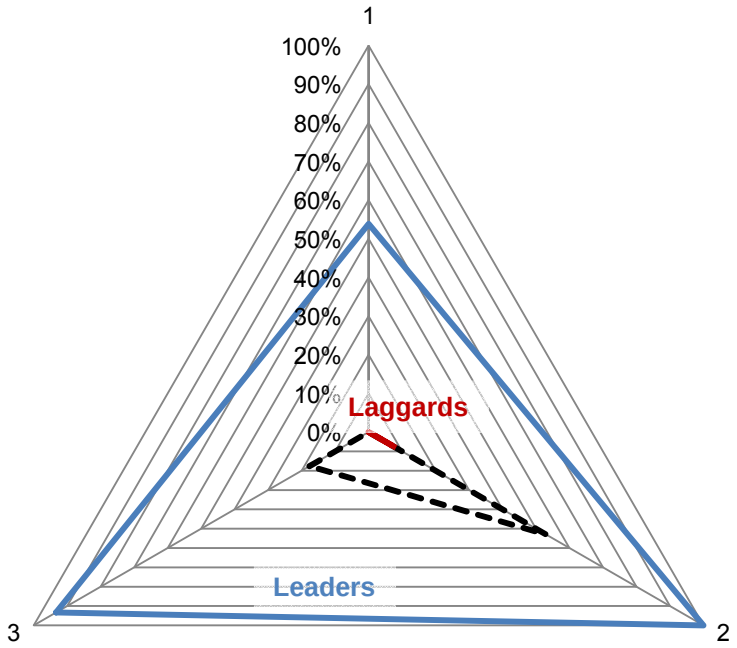
5 - Total full-time telecommunications staff (per 100 people) (*)

6 - GDP per Telecom Employee (US Dollars) (*)

% of countries that scored “high” on indicator per cluster
(*): p<0.01 (**): p<0.05 (***): p<0.1

Results: characterization of stages

Digital Literacy



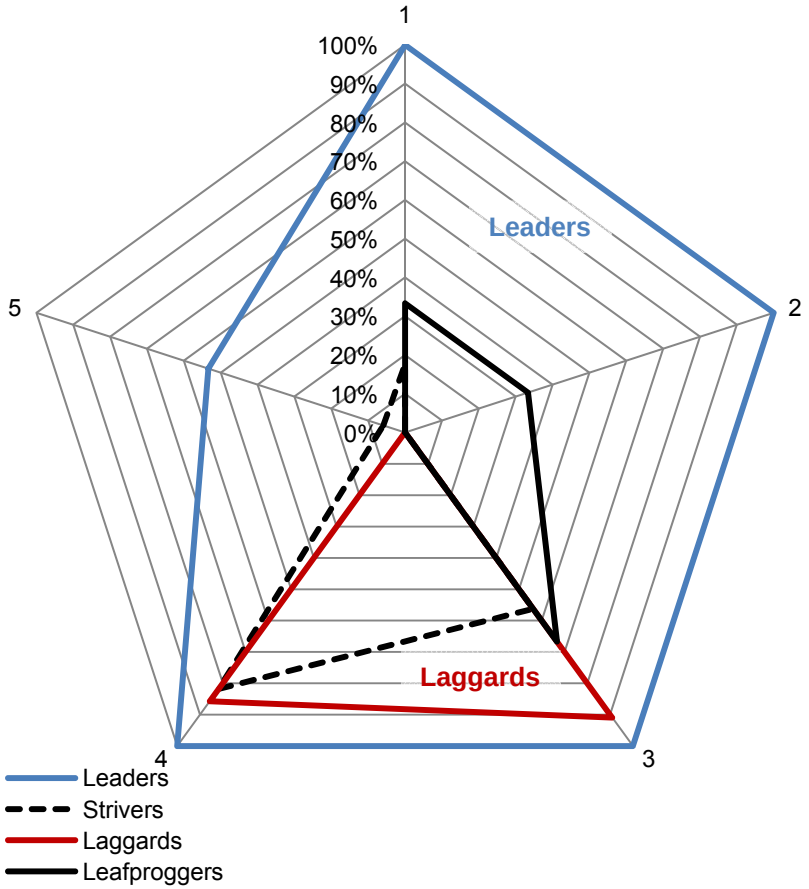
1 - Enrolment in science. Tertiary. (per 100 people) (*)

2 - Human Capital (*)

3 - Internet Access in Schools (*)

% of countries that scored “high” on indicator per cluster
(*): p<0.01 (**): p<0.05 (***): p<0.1

Policy and regulatory framework



1 - Laws relating to ICT (*)

2 - Intellectual property protection (*)

3 - Level of competition - DSL (**)

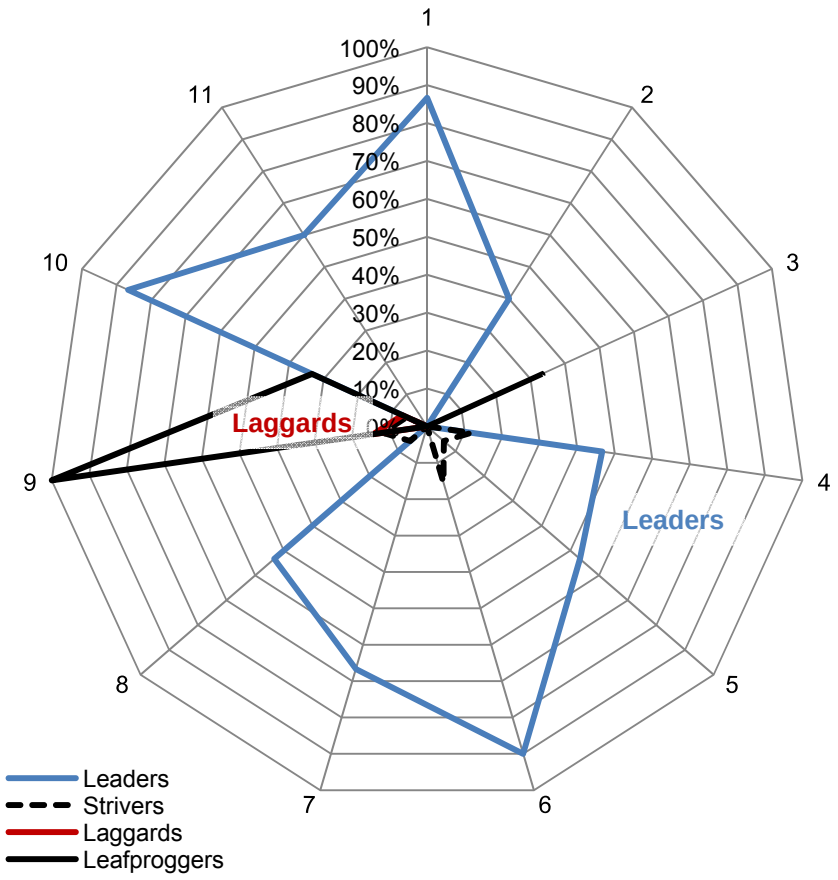
4 - Level of competition – Cable modem (**)

5 - Gov't procurement of advanced tech products (*)

% of countries that scored “high” on indicator per cluster
(*): p<0.01 (**): p<0.05 (***): p<0.1

Results: characterization of stages

Usage



1 - Secure Internet servers (per 1 million people) (*)

2 - Total Domains (per 100 people) (*)

3 - Total ICT Spending, Retail Trade (% of GDP) (*)

4 - Web Measure (*)

5 - Availability of government online services (*)

6 - International outgoing telephone traffic (minutes) (per 100 people) (*)

7 - Internet users (per 100 people) (*)

8 - E-Participation (*)

9 - Total ICT Spending, Consumer (% of GDP) (*)

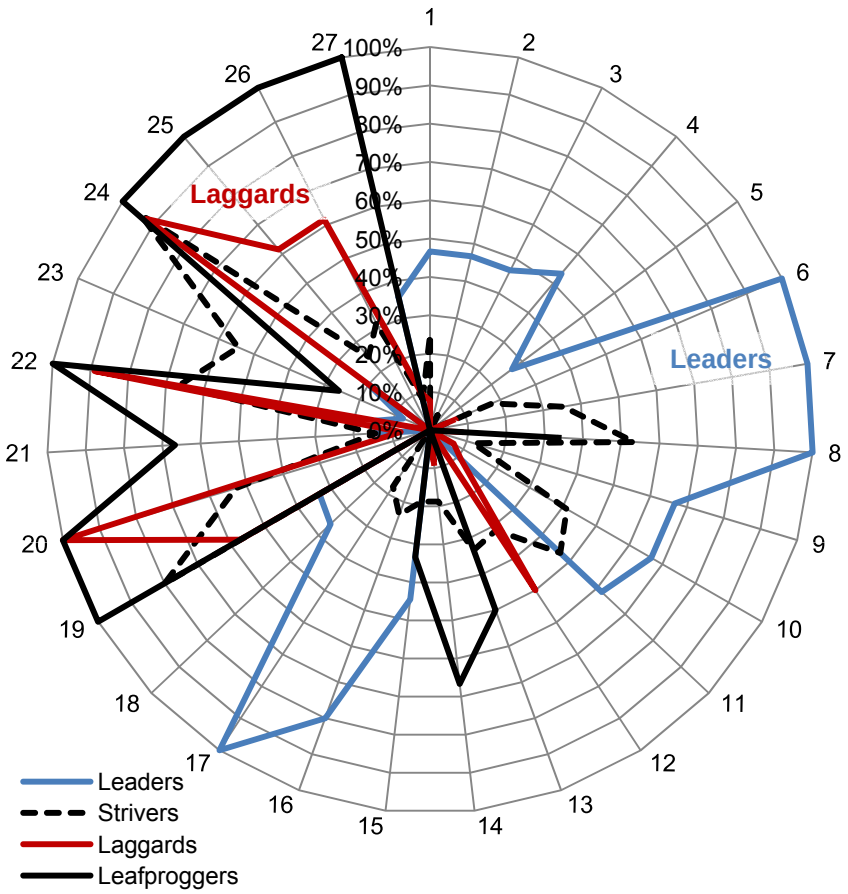
10 - Firm-level technology absorption (*)

11 - Extent of business Internet use (*)

% of countries that scored “high” on indicator per cluster
(*): p<0.01 (**): p<0.05 (***): p<0.1

Results: characterization of stages

Analogue indicators



% of countries that scored “high” on indicator per cluster
(*): p<0.01 (**): p<0.05 (***): p<0.1

1 - GDP (***)
2 - GDP Capita (*)
3 - GDP per capita, PPP (current international $) (*)
4 - GNI per capita, Atlas method (current US$) (*)
5 - GNI per capita, PPP (current international $) (**)
6 - HDI (*)
7 - Life expectancy at birth, total (years) (*)
8 - Improved water source (% of population with access) (*)
9 - Health Public Expenditure (% of govt. expenditure) (*)
10 - Health Public Expenditure (% of total Health expend.) (*)
11 - School enrollment, primary (% net) (***)
12 - School enrollment, primary (% gross) (**)
13 - Education Public Expenditure (% of govt. expenditure) (***)
14 - Gross National Expenditure (% of GDP) (**)
15 - General Govt. final consumption expend. (% of GDP) (***)
16 - Economic Incentive Regime (*)
17 - Innovation (*)
18 - Population in urban agglom. > 1 million (% of total pop.) (*)
19 - Inequality-10 (**)
20 - Mortality rate, infant (per 1,000 live births) (*)
21 - Population growth (annual %) (***)
22 - Interest payments (% of GDP) (*)
23 - Present value of debt (% of GNI) (**)
24 - GDP deflator (base year varies by country) (*)
25 - Inflation, consumer prices (annual %) (*)
26 - Inflation, GDP deflator (annual %) (*)
27 - Tax revenue (% of GDP) (**)

Determinants: digital leaders

logit(ZCLUSTER54_CB) = β1 • GEN30 + β2 • GEN05 + β3 • GEN07 + β4 • GEN08 + β5 • LEGAL_D_04+ ε

Binary logistic regression with digital leaders (1 is a digital leader, 0 is not a digital leader) as the dependent variable.

	B	S.E.	Wald	df	Sig.	Exp(B)
Life expectancy at birth, total (GEN30)	-.399	.208	3.664	1	.056	.671
Inequality-20 (GEN05)	-1.066	.578	3.403	1	.065	.344
Urban Population (%) (GEN07)	.138	.079	3.030	1	.082	1.148
Economic Incentive Regime (GEN08)	1.671	.877	3.628	1	.057	5.317
Government prioritization of ICT (LEGAL_D_04)	2.869	1.737	2.727	1	.099	17.611

N	46		
Correctly predicted cases	95.7%	96.8% (leaders)	93.3% (rest)
-2 Log likelihood	15.970		
Cox & Snell R-square	.646		
Nagelkerke R-square	.862		
Chi-Square (sig)	47.799	(.000)	
Hosmer and Lemeshow Test Chi-Square (sig)	1.546	(.981)	

Determinants: digital laggards

$$\text{logit}(ZCLUSTER54\_CBL) = \beta 0 + \beta 1 \bullet GEN06 + \beta 2 \bullet GEN14 + \beta 3 \bullet INF\_S\_06 + \beta 4 \bullet LEGAL\_D\_01 + \varepsilon$$

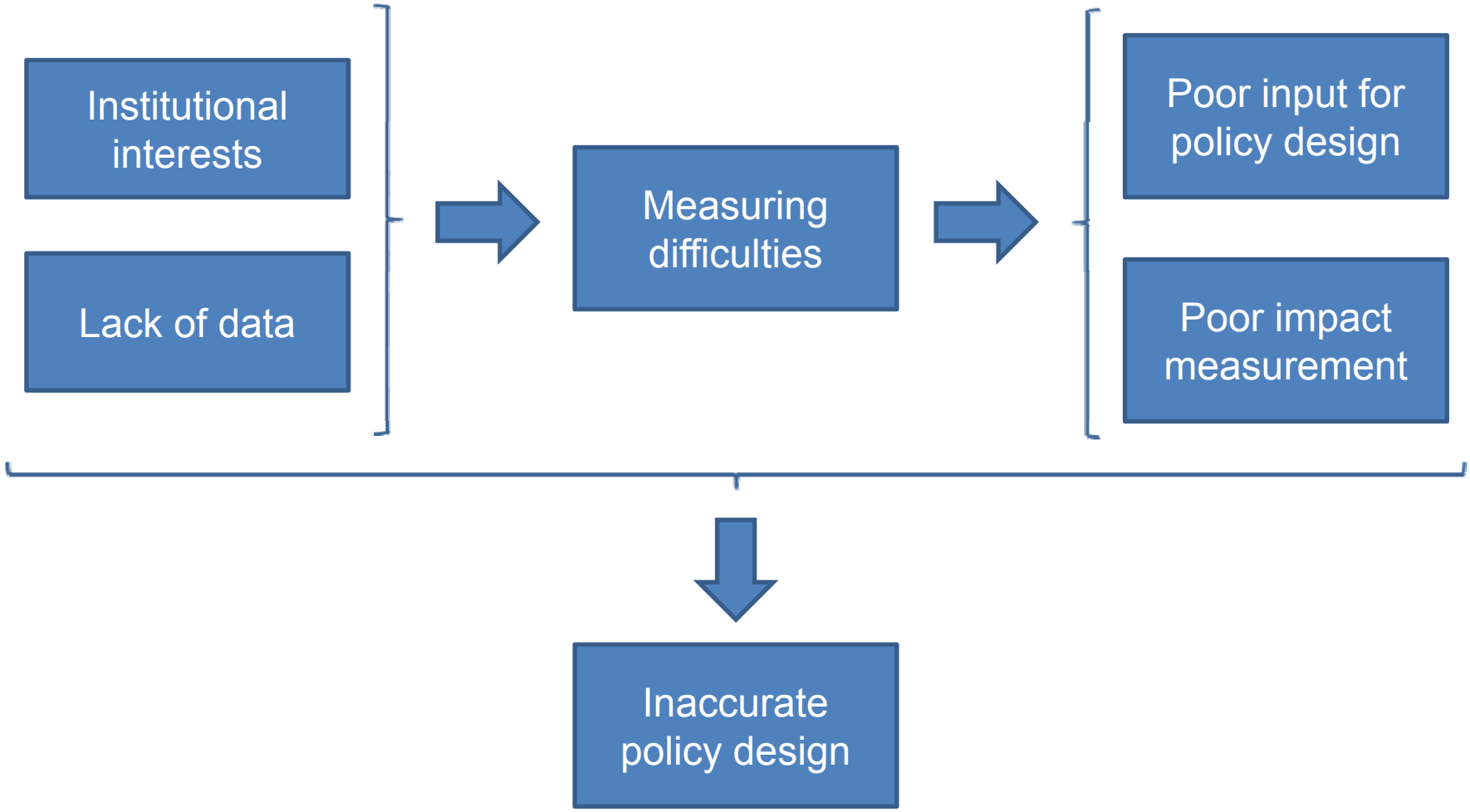
Binary logistic regression with digital leaders (1 is a digital laggard, 0 is not a digital laggard) as the dependent variable.

	B	S.E.	Wald	df	Sig.	Exp(B)
Constant	38.214	16.958	5.078	1	.024	$3.945 \cdot 10^{16}$
Inequality-10 (GEN06)	-.235	.138	2.909	1	.088	.790
Health Public Expenditure (% of total Health expenditure) (GEN14)	-.176	.081	4.665	1	.031	.839
Population covered by mobile telephony (%) (INF_S_06)	-.100	.050	3.936	1	.047	.905
Importance of ICT to government vision of the future (LEGAL_D_01)	-4.304	2.239	3.696	1	.055	.014

N	47		
Correctly predicted cases	94.6%	96.4% (laggards)	88.9 % (rest)
-2 Log likelihood	11.391		
Cox & Snell R-square	.551		
Nagelkerke R-square	.823		
Chi-Square (sig)	29.663	(.000)	
Hosmer and Lemeshow Test Chi-Square (sig)	3.684	(.815)	

Conclusions

Working hypothesis #1



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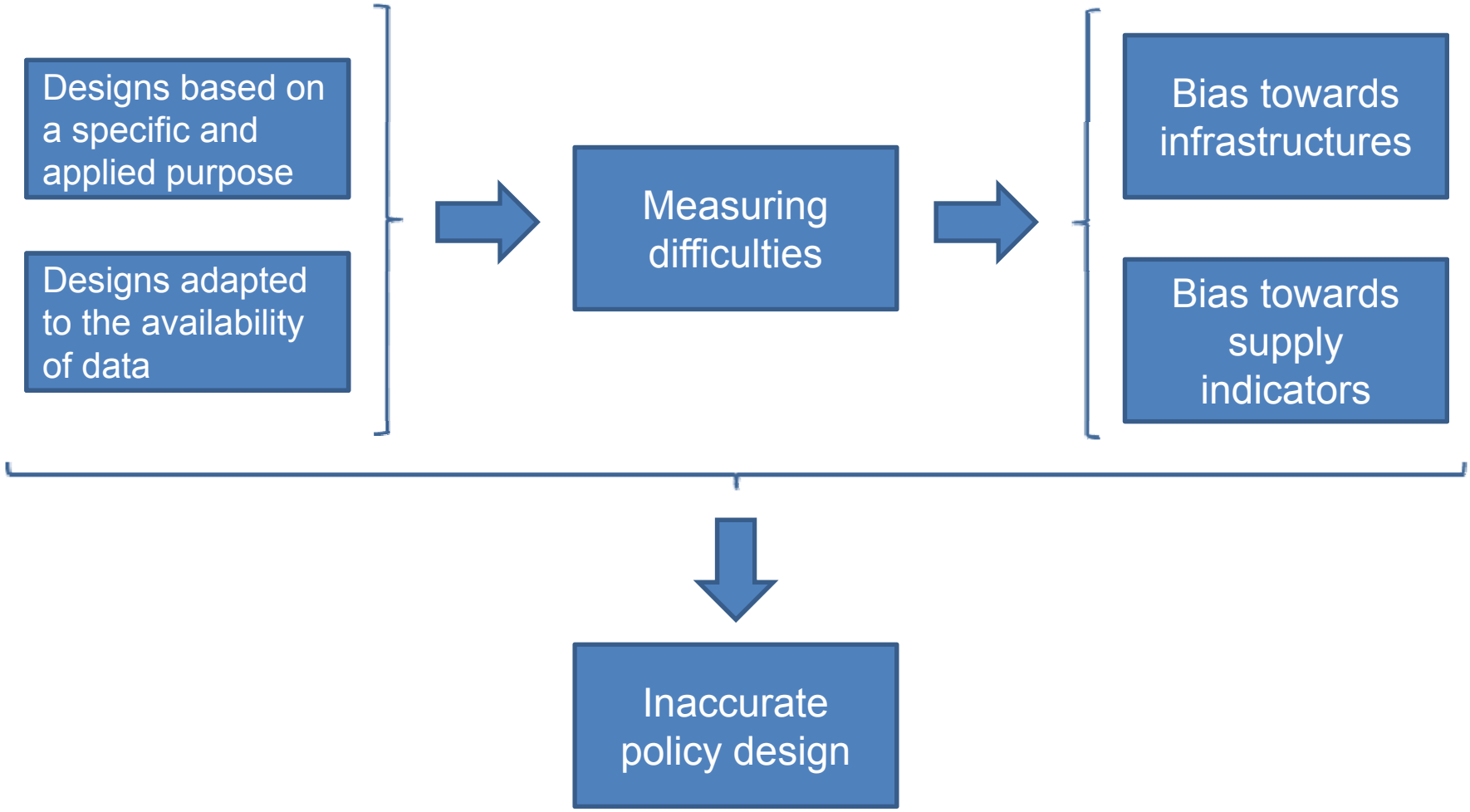
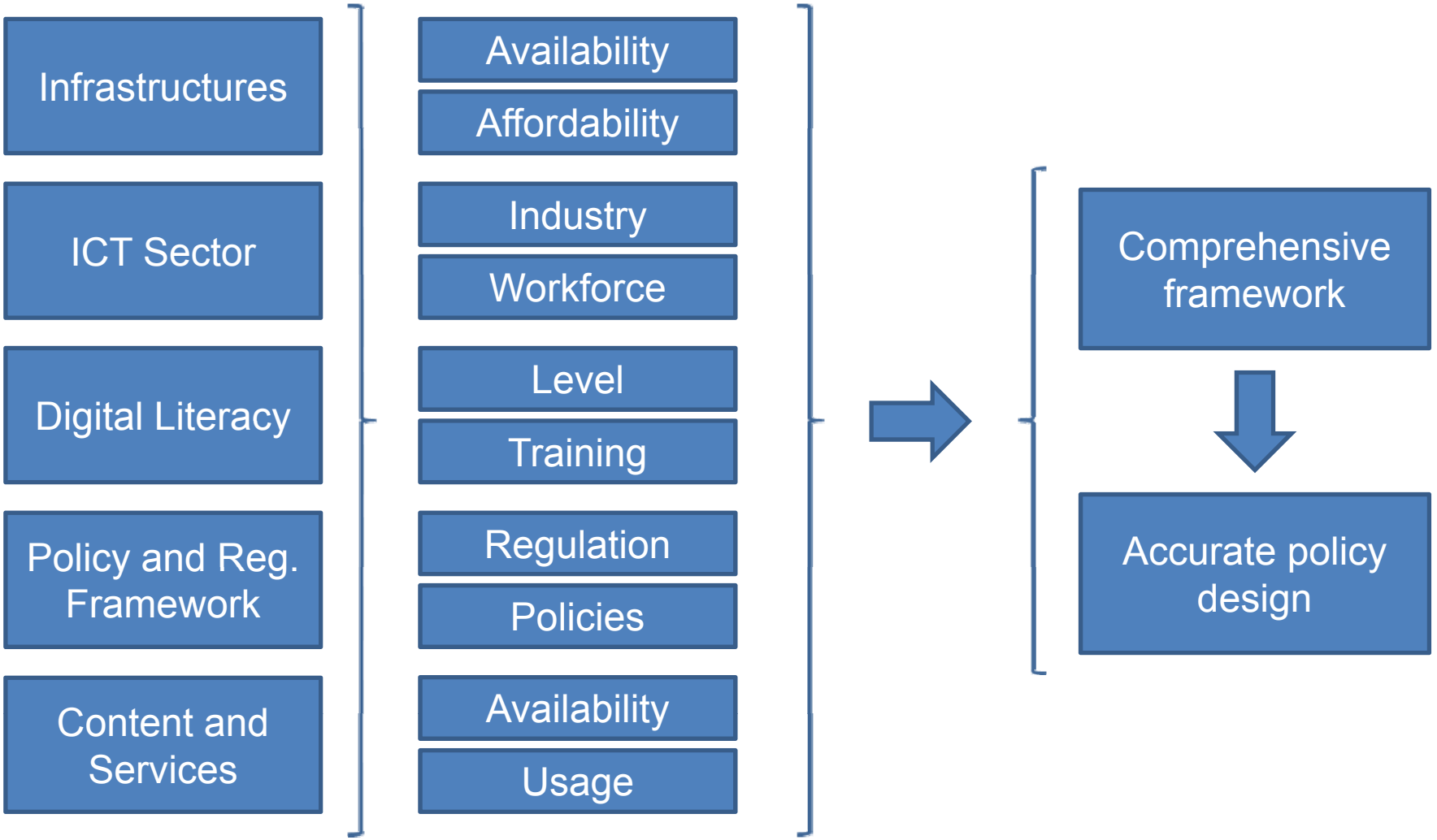
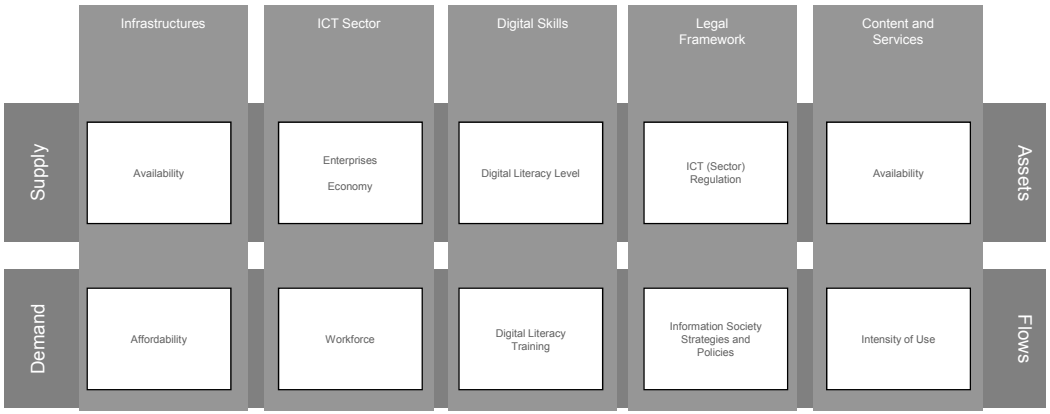


Working hypothesis #2



Working hypothesis #2



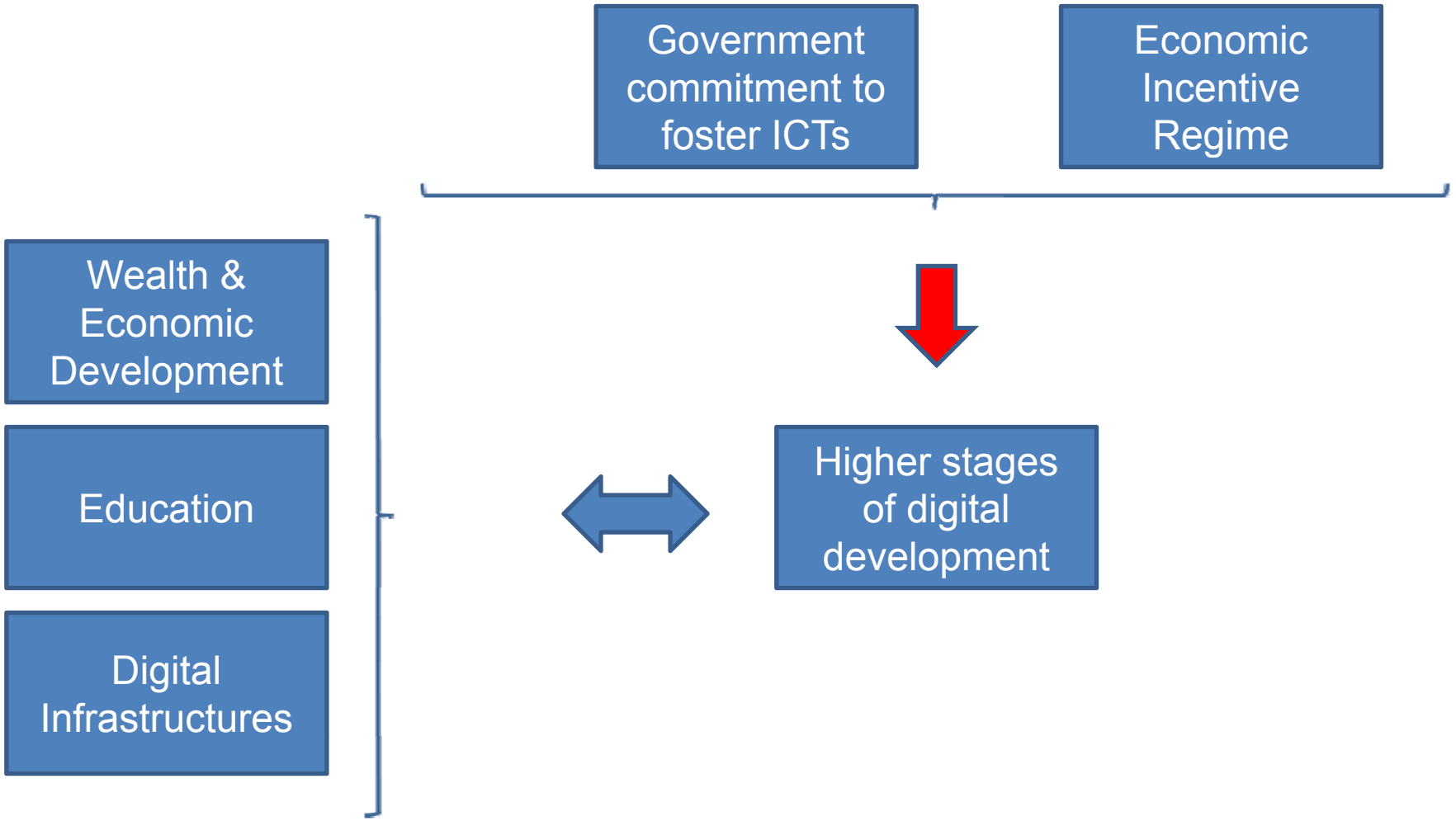
Comprehensive: Gathers all approaches

Meets theory and empiricism

Enables ICT vs. Dev. comparisons

Measures policy impact

Working hypothesis #3



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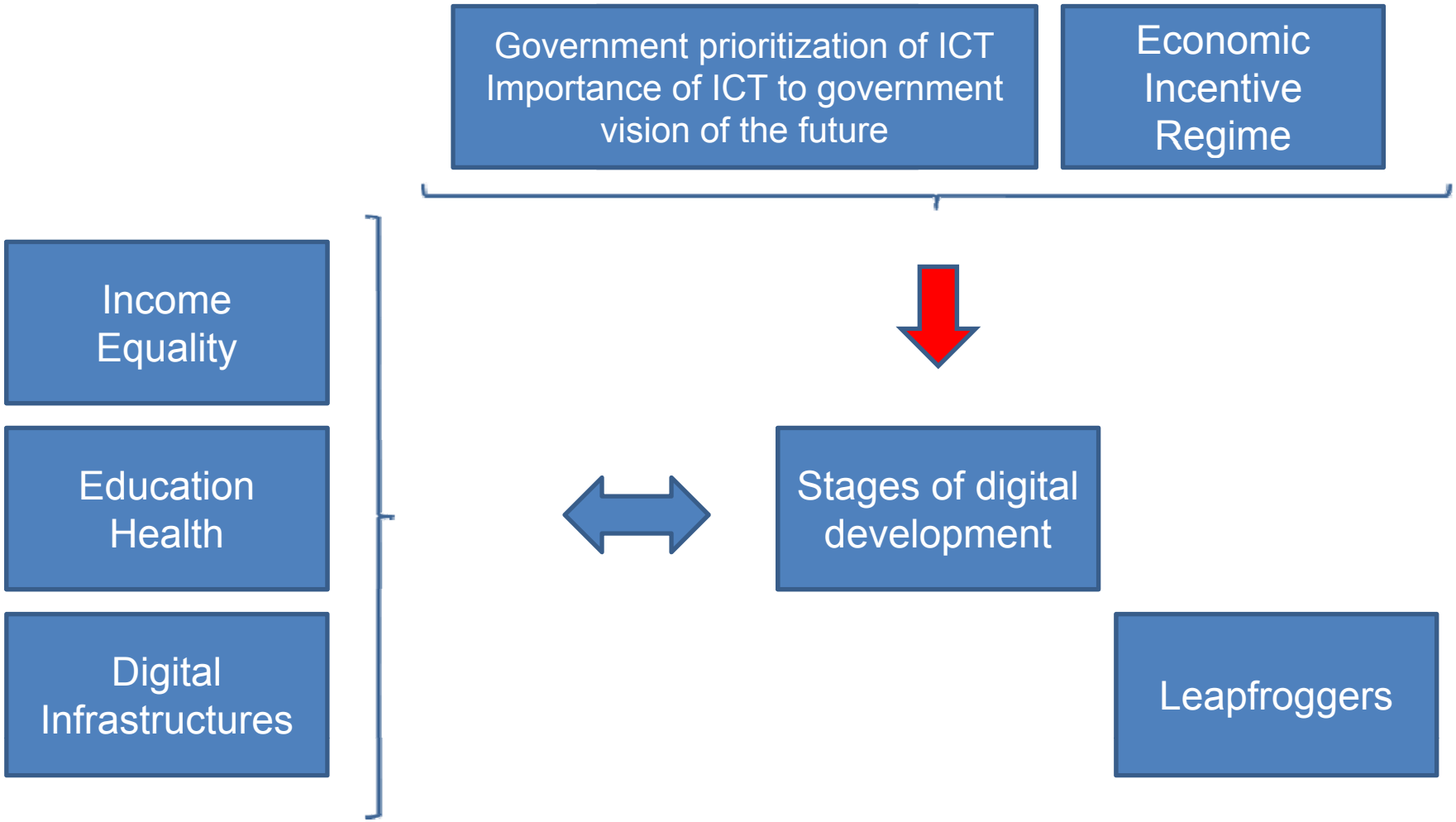
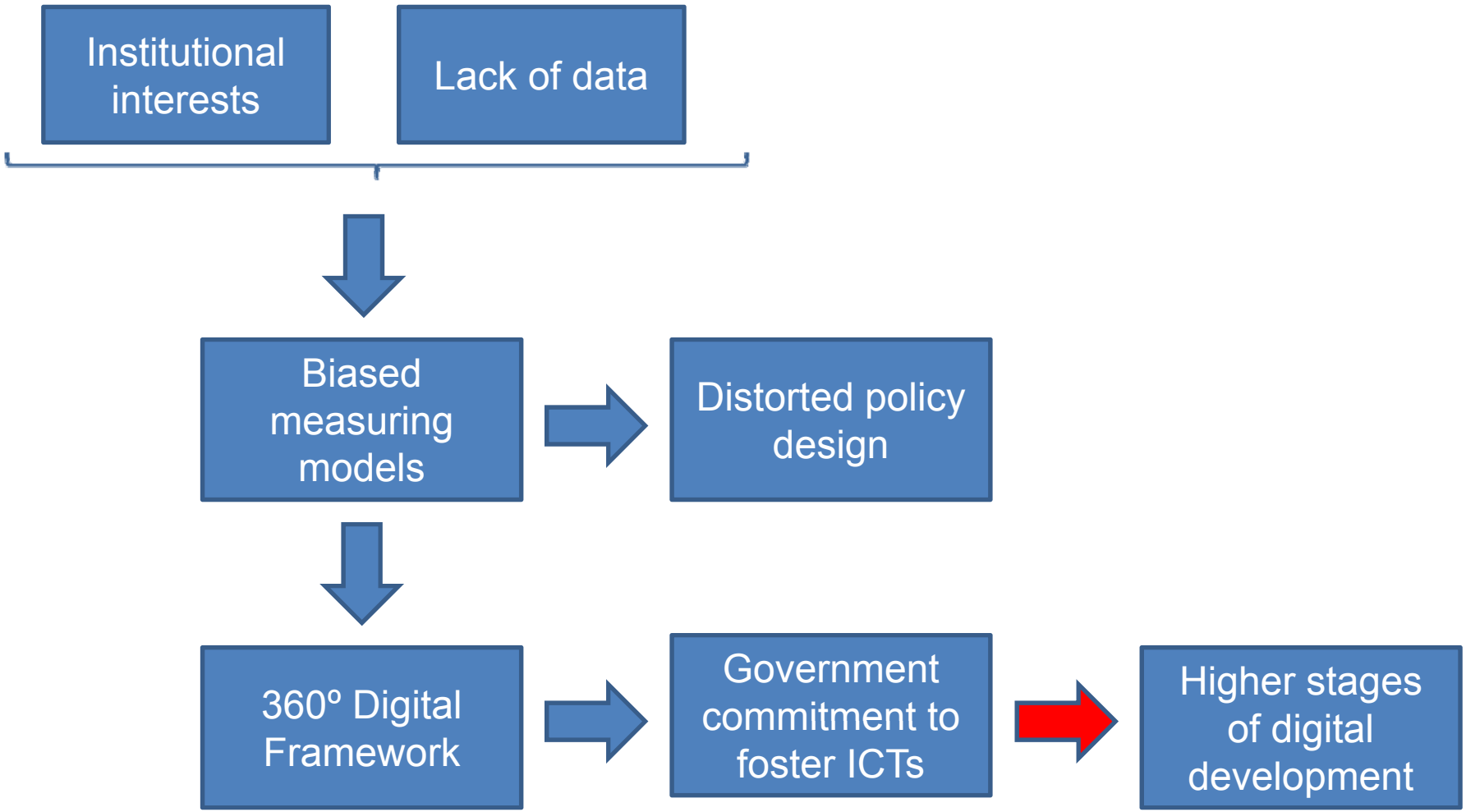


General hypothesis



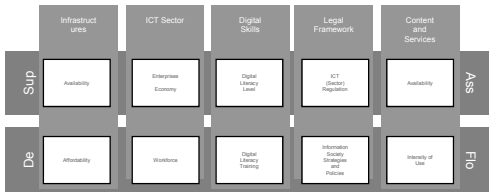
General hypothesis

Designs based on a specific and applied purpose

Designs adapted to the availability of data

Inaccurate measuring models

Inaccurate policy design



Government commitment to foster ICTs

Eco. Incentive Regime

Higher stages of digital development

Limitations of the research

- Theoretical framework to be improved: pros and cons of multidisciplinary research, theory vs. practice
- Quality of data: coverage, soft data, lack of data
- Quantity of data: time series, geographic coverage, loss of detail due to aggregation
- Significance of models

Future lines of research

Future lines of research

- Strengthen the links between theory and practice
  - Towards multidisciplinary frameworks
- *Übercomprehensive* model: Structural equation modelling
  - Simultaneousness, complex systems, network effects
  - Dynamic (time) analysis
- How and *why* Leapfrogging
- Design of Public policies to foster the Information Society

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