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

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Internet Users Year 2007

Data from International Telecommunication Union

www.worldmapper.org
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Why this research
Components of human development

- Socioeconomic development
- Individual resources
- Objective choice
- Value change
- Emancipative values
- Subjective choice
- Democratization
- Freedom rights
- Effective choice

Adapted from Welzel et al. (2003)
Social structures (& Network Society)

Matter (nature) → Relationships of Production

Relationships of Experience

Relationships of Power → Culture

Adapted from Castells, M. (2000)
## The Digital Economy as an enabler

<table>
<thead>
<tr>
<th>Development</th>
<th>The Digital Economy</th>
<th>Network Society</th>
</tr>
</thead>
<tbody>
<tr>
<td>Socioeconomic Development</td>
<td>INFRASTRUCTURES</td>
<td>Matter (nature)</td>
</tr>
<tr>
<td>(individual resources)</td>
<td>ICT SECTOR</td>
<td>Production</td>
</tr>
<tr>
<td>Value Change</td>
<td>(DIGITAL) LITERACY</td>
<td>Experience</td>
</tr>
<tr>
<td>(emancipative values)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Democratization</td>
<td>LEGAL FRAMEWORK</td>
<td>Power</td>
</tr>
<tr>
<td>(freedom rights)</td>
<td>USES (CONTENT &amp; SERVICES)</td>
<td>Culture</td>
</tr>
</tbody>
</table>

Source: author
Fostering access to the Digital Economy


**General hypothesis**

- Institutional interests
- Lack of data
  - Inaccurate measuring models
  - Inaccurate policy design
    - Comprehensive framework
    - Government commitment to foster ICTs
      - Higher stages of digital development
Working hypothesis #1

Institutional interests

Lack of data

Measuring difficulties

Poor input for policy design

Poor impact measurement

Inaccurate policy design
Working hypothesis #2

Infrastructures
ICT Sector
Digital Literacy
Policy and Reg. Framework
Content and Services

Availability
Affordability
Industry
Workforce
Level
Training
Regulation
Policies
Availability
Usage

Comprehensive framework
Accurate policy design
Working hypothesis #3

- Government commitment to foster ICTs
- Economic Incentive Regime
- Higher stages of digital development

- Wealth & Economic Development
- Education
- Digital Infrastructures
Methodology
Proposed model: 360° Digital Framework

Methodology

Infrastructures
- Availability

ICT Sector
- Enterprises Economy
- Digital Literacy Level
- ICT (Sector) Regulation
- Availability

Content and Services
- Affordability
- Workforce
- Digital Literacy Training
- Information Society Strategies and Policies
- Intensity of Use

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 360° Digital Framework
- Critique
Quantitative analysis: statistics

1. Analysis of Variables:
   - correlations
   - standardization
   - dichotomization

2. Factor Analysis

3. Cluster Analysis

4. Characterization

5. Logistic regressions

Relationships between variables

Stages of digital development:
- Clusters (WITSA)
- Clusters (OECD)

4 stages of digital development and its characteristics:
- WITSA countries
- OECD countries

Determinants of stages of digital development:
- WITSA countries
Quantitative analysis: statistics

14 databases, 157 variables, 257 countries, year ~2007

1. Analysis of Variables:
   - correlations
   - standardization
   - dichotomization

Dichotomized variables

2. Factor Analysis
   - standardization
   - dichotomization

Standardized variables

Non conclusive

3. Cluster Analysis

49 countries, 22 vars. (WITSA)
28 countries, 17 vars. (OECD)

Stages of digital development:
Clusters (WITSA)
Clusters (OECD)

4. Characterization

65 vars. (WITSA)
53 vars. (OECD)

4 stages of digital development and its characteristics:

5. Logistic regressions

Determinants of stages of digital development:

2 regressions
## Bridging theory and practice

<table>
<thead>
<tr>
<th></th>
<th>Infrastructures</th>
<th>ICT Sector</th>
<th>Digital Skills</th>
<th>Policy and Regulatory Framework</th>
<th>Content and Services</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Supply/Assets</strong></td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td><strong>Demand/Flows</strong></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th>Infrastruct.</th>
<th>ICT Sector</th>
<th>Digital Skills</th>
<th>Policy and Regulatory Framework</th>
<th>Content and Services</th>
<th>Nondigital</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Supply/Assets</strong></td>
<td>8</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>27</td>
</tr>
<tr>
<td><strong>Demand/Flows</strong></td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

Indicators (vars.) used to characterize the stages of digital development (WITSA)
Results
Results: qualitative analysis

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)

Distribution of the aggregate categories – including analogue indicators

- Nondigital: 24%
- Demand/Flow: 25%
- Supply/Stock: 51%

Distribution of the aggregate categories – including analogue indicators

- Demand/Flow: 33%
- Supply/Stock: 67%

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

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

Non-hierarchical K-means cluster analysis.
Significance of F in ANOVA for all variables: p<0.001
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)
2. Personal computers (per 100 people)
3. Telephone mainlines (per 100 people)
4. International Internet bandwidth (bits per person)
5. Internet Hosts (per 10000 people)
6. GDP per Telecom Employee (US Dollars)
7. Human Capital
8. Internet Access in Schools
9. Laws relating to ICT
10. Intellectual property protection
11. Gov't procurement of advanced tech products
12. Secure Internet servers (per 1 million people)
13. Total Domains (per 100 people)
14. Availability of government online services
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
**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
(\(^*\)): \(p<0.01\) \(\text{(**)}: p<0.05\) \(\text{(***)}: p<0.1\)
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
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

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) (**)

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

\[
\text{logit}(\text{ZCLUSTER54_CB}) = \beta_1 \cdot \text{GEN30} + \beta_2 \cdot \text{GEN05} + \beta_3 \cdot \text{GEN07} + \beta_4 \cdot \text{GEN08} + \beta_5 \cdot \text{LEGAL_D_04} + \epsilon
\]

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

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

N = 46
Correctly predicted cases: 95.7% (leaders) 96.8% (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

### Results: logit regressions

\[
\text{logit(ZCLUSTER54\_CBL)} = \beta_0 + \beta_1 \times \text{GEN06} + \beta_2 \times \text{GEN14} + \beta_3 \times \text{INF\_S\_06} + \beta_4 \times \text{LEGAL\_D\_01} + \epsilon
\]

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

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>38.214</td>
<td>16.958</td>
<td>5.078</td>
<td>1</td>
<td>.024</td>
<td>3.945\times10^{16}</td>
</tr>
<tr>
<td>Inequality-10 (GEN06)</td>
<td>-.235</td>
<td>.138</td>
<td>2.909</td>
<td>1</td>
<td>.088</td>
<td>.790</td>
</tr>
<tr>
<td>Health Public Expenditure (% of total Health expenditure) (GEN14)</td>
<td>-.176</td>
<td>.081</td>
<td>4.665</td>
<td>1</td>
<td>.031</td>
<td>.839</td>
</tr>
<tr>
<td>Population covered by mobile telephony (%) (INF_S_06)</td>
<td>-.100</td>
<td>.050</td>
<td>3.936</td>
<td>1</td>
<td>.047</td>
<td>.905</td>
</tr>
<tr>
<td>Importance of ICT to government vision of the future (LEGAL_D_01)</td>
<td>-4.304</td>
<td>2.239</td>
<td>3.696</td>
<td>1</td>
<td>.055</td>
<td>.014</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N</th>
<th>47</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correctly predicted cases</td>
<td>94.6%</td>
</tr>
<tr>
<td>-2 Log likelihood</td>
<td>11.391</td>
</tr>
<tr>
<td>Cox &amp; Snell R-square</td>
<td>.551</td>
</tr>
<tr>
<td>Nagelkerke R-square</td>
<td>.823</td>
</tr>
<tr>
<td>Chi-Square (sig)</td>
<td>29.663 (.000)</td>
</tr>
<tr>
<td>Hosmer and Lemeshow Test Chi-Square (sig)</td>
<td>3.684 (.815)</td>
</tr>
</tbody>
</table>
Conclusions
Conclusions

Working hypothesis #1

- Institutional interests
- Lack of data

Measuring difficulties

- Poor input for policy design
- Poor impact measurement

Inaccurate policy design
Conclusions

Working hypothesis #1

- Designs based on a specific and applied purpose
- Designs adapted to the availability of data

Measuring difficulties

- Bias towards infrastructures
- Bias towards supply indicators

Inaccurate policy design
Working hypothesis #2

- Infrastructures
- ICT Sector
- Digital Literacy
- Policy and Reg. Framework
- Content and Services

- Availability
- Affordability
- Industry
- Workforce
- Level
- Training
- Regulation
- Policies
- Availability
- Usage

Comprehensive framework
Accurate policy design
Conclusions

Working hypothesis #2

Comprehensive: Gathers all approaches
Meets theory and empiricism
Enables ICT vs. Dev. comparisons
Measures policy impact
Working hypothesis #3

- Government commitment to foster ICTs
- Economic Incentive Regime

- Higher stages of digital development
- Wealth & Economic Development
- Education
- Digital Infrastructures
Working hypothesis #3

- Government prioritization of ICT
  Importance of ICT to government vision of the future
- Economic Incentive Regime
- Income Equality
- Education
- Health
- Digital Infrastructures
- Stages of digital development
- Leapfroggers

Higher stages of digital development lead to leapfroggers.
General hypothesis

- Institutional interests
- Lack of data

- Biased measuring models
- Distorted policy design

- 360º Digital Framework
- Government commitment to foster ICTs

- Higher stages of digital development
Conclusions

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

To cite this work:

References used in this presentation:
http://ictlogy.net/bibciter/reports/bibliographies.php?idb=2

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