Towards a comprehensive model of the digital economy

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***Abstract*—In this research we test the hypothesis that institutional interests and lack of data have led to fragmented models to measure digital development, thus distorting policy design. A qualitative analysis was performed on 55 different models (including composite indices) that have been defined, applied and or/used to describe and measure digital development in the last years.**

We will show that most of them can be grouped in two — the telecommunications and the e-readiness models — in which the representation of different categories of digital development are unbalanced, biased towards the supply side; they could notably be improved both in quantity (scope) and quality and are usually insufficient to assess the impact of public policies in fostering the Information Society or the use of ICTs for development.

We will state that a more comprehensive framework would improve such models and help in the adoption of public policies that would lead to higher stages of digital development.

***Index Terms*— e-readiness, digital divide, policy, information society, digital economy, composite indices**

I. Introduction

In the last years we have witnessed an effort to describe the impact of Information and Communication Technologies on society. Some concepts have aroused as Digital Development, Information Society, Knowledge based societies, Network Society... and above all, the needs to make the evolution of these theoretical constructs measurable. This effort has served many purposes, being the more relevant (a) explaining what was the impact of Information and Communication Technologies (ICTs) on Society, (b) measuring this impact and (c) designing policies to foster positive impacts while reducing negative ones, among the mere access and usage of the afore mentioned ICTs (normally referred to as the digital divide).

Beyond – or within – general theoretical approaches, applied models have been built to identify the core aspects that made up a particular understanding of the interaction of ICTs and Society, and tried to draw the relationships amongst these aspects. In some cases, the translation of these issues into specific indicators made possible the measurement of the evolution of ICTs and Society – as understood by each model – and the establishment of relationships of cause within models, relationships upon which policies were to be built.

In the following pages we identify and analyze what have been the main models to quantitatively describe and measure Digital Development, understood as the results of the process of digitization of society and its economy, and the prior or first stage upon which more complex theories are based upon.

First, we focus on the theoretical and methodological proposals for modelling Digital Development. We are particularly interested in their conceptual approach, although some of these models have been applied also in surveys and assessments. When not applied, these models have framed future understandings and designs of more practical models. We secondly switch to cases of actual implementation, that is, sets of indicators and composite indices aimed at measuring the development of the Information Society and that have either explicitly come after explicit modelling of Digital Development or implicitly embody underlying theoretical models.

We have deliberately set aside public policies to promote the Digital Development for two main reasons. The first one because we want to be as close as possible of what has been really done and not what was said that was going to be. The second one because the results of these policies must be properly measured to realize their real achievements; in doing so – measuring – we see tacit models emerge from daily practice. It is thus by approaching the tools that we can proxy and infer the actual models implemented.

II. Methodology

To perform our analysis we chose 55 models that depicted Digital Development, most of them created and/or in use between 1995 and the first months of 2009, when the research was finished. We then categorized and counted the number indicators they used. Through a qualitative analysis of the distribution across categories of these indicators we were able to infer the conclusions that appear at the end of this paper.

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TABLE I
MODELS

Name	Promoter	Period.	#C	From	To
African ICT e-Index	Research ICT Africa	NP	16	2002	2007
ArCo	Archibugi & Coco	NP	86	2000	2000
Basic Knowledge Economy Scorecard	The World Bank	A	140	1995	2008
Broadband Performance Index	European Commission	NP	28	2008	2008
Comprehensive Metric	Barzilai-Nahon, K.	NO	0		
Connectivity Scorecard - Efficiency and Resource Driven Economies	Waverman et al.	A	25	2007	2008
Connectivity Scorecard - Innovation Driven Economies	Waverman et al.	A	25	2007	2008
Core ICT Indicators	Partnership on Measuring ICT for Development	NO	0		
Core ICT Indicators for the ECA region	Economic And Social Commission For Western Asia	N	53		
Core ICT Indicators for the ESCWA region	Economic And Social Commission For Western Asia	N	13		
Digital Access Index	International Telecommunication Union	NP	146	2002	2002
Digital Divide Index	SIBIS	NP	25	1997	2002
Digital Divide Index - Infostate	Orbicom	A	191	1995	2003
Digital Opportunity Index	International Telecommunication Union	A	181	2005	2006
Digital Planet	World Information Technology and Services Alliance	A	75	2001	2007
E-Commerce Readiness Assessment Guide	APEC e-Commerce Readiness Initiative	NO	0		
E-Commerce Readiness in East Asian APEC Economies	Bui, T. X., Sebastian, I. M., Jones, W. & Naklada, S.	NP	10	2001	2001
e-Government Readiness Index	UNPAN	3A	192	2002	2007
e-Participation Index	UNPAN	3A	192	2002	2007
e-Readiness Guide (GeoSINC)	GeoSINC	NO	0		
e-Readiness Rankings	The Economist Intelligence Unit	A	70	2000	2007
European Information Society Statistics	European Commission	6M	27	2002	2007
Freedom on the Net Index	Freedom House	A	15	2008	2008
Global Action Plan for Electronic Commerce	WITSA	NO	0		
Global E-Readiness	McConnell International	NP	53	1999	2000
Global Internet Filtering	OpenNet Initiative	NP	40	2007	2007
ICT at a Glance Tables	The World Bank	A	207	2000	2006
ICT Development Index	International Telecommunication Union	A	154	2002	2007
ICT Diffusion Index	UNCTAD	A	180	2002	2004
ICT Opportunity Index	UNCTAD	A	183	2004	2006
Index of Knowledge Societies	UNPAN	NP	40	2005	2005
Information Society Index	IDC	A	53	1995	2007
Knowledge Economy Index	The World Bank	A	140	1995	2009
Knowledge Index	The World Bank	A	140	1995	2008
Layers, Sectors and Areas of the Information Society	Hilbert, M. R. & Katz, J.	NO	0		
Models of Access	Warschauer, M.	NO	0		
Networked Readiness Index	World Economic Forum	A	134	2001	2008
OECD Key ICT Indicators	Organisation for Economic Co-operation and Development	A	32	1991	2007
PISA	Organisation for Economic Co-operation and Development	3A	40	2003	2006
Readiness for the Networked World. A Guide for Developing Countries	CID Harvard University	NO	0		
Readiness Guide for Living in the Networked World	Computer Systems Policy Project	NO	0		
Real Access Criteria	Bridges.org	NO	0		
SIBIS Framework	SIBIS	NP	17	2002	2002
SIMBA Model	Wikander, G.	NP	8	2005	2005
Sustainable ICT Framework	Sundén, S. & Wikander, G	NP	1	2000	2000
Technology Achievement Index	UNDP	NP	72	2000	2000
The Access Rainbow	Clement, A. & Shade, L.R.	NO	0		
The CTO Guide to the ICT	Commonwealth Telecommunications Organization	NP	54	1999	2001
The Development Dynamic	Accenture, Markle Foundation & UNDP	NO	0		
The eInclusion Index	SIBIS	NO	0		
The Global Diffusion of the Internet	Mosaic	NP	25	1997	2000
WDI Key ICT Indicators	The World Bank	A	211	2000	2006
World Development Indicators – The information Age	The World Bank	A	153	1995	2008
World Telecommunication ICT Indicators	International Telecommunication Union	A	209	1975	2008
World Telecommunication Regulatory Database	International Telecommunication Union	A	191	1998	2008

Periodicity: NO: never measured; NP: non periodical; A: annual; 3Y: every three years; 6M: half-yearly; 3M: every 3 months. #C: number of economies covered. Please see [1]-[46] for the sources used.

A. Models that describe Digital Development

Our analysis covered 55 models (see Table I) that labelled themselves as describing the Information Society, the Digital Divide, the Digital Economy or other related concepts. We grouped them into four categories according to their degree of application:

a) Descriptive models: attempts to draw structures and rationales about the Digital Economy without the direct observation of any data, just relying on changes of patterns, trends and qualitative impacts that scientists have witnessed in the society.

b) Theoretical models: proposals to measure the Digital Economy whose origin comes from a theoretical reflection or analysis, but, differently from the case of the Descriptive Models, Theoretical Models have indeed come to practice at least once so to test them against real data.

c) Composite Indices: measurement models that have been repeated over time, so that a comparison of the chronological changes and trends is made possible. These indices either have their origin in a positive or a normative approach, but have been improved along the different editions issued e.g. yearly, thus evolving into an applied tool and a theoretical model that depicts some conception of the Information Society. A second main characteristic of these indices is that they are applied at the international level and, given the nature of the index, allow direct comparisons between countries.

d) Sets of indicators: strictly speaking, these are not explicit models since the purpose of the sets of indicators is not the conceptualization of the Information Society, but to provide data (raw or slightly treated) that other models may use as an input. We include them here because, despite its apparent neutrality or objectivity, there is a more or less implicit (and sometimes even explicit) model that drives the selection of such variables and indicators

B. Categorization of indicators within the models

To draw the main theoretical categories, we conducted a recursive, or iterative, exercise throughout all the analyzed models. Thus, after an initial exploration of the categories in which each model classified the indicators it used, we ended up designing our own system of categorization, which is the one reflected in Table II:

The definitions of each primary and secondary categories are as follows:

1) Infrastructures: Information and Communication Technologies. They are divided into three groups: hardware, software and connectivity.

1a) *Infrastructures, Availability*: the mere existence of these infrastructures.

TABLE II
COMPREHENSIVE 360º DIGITAL FRAMEWORK
CATEGORIES OF INDICATORS

Primary categories	Secondary categories	
Infrastructures	Availability	Affordability
ICT Sector	Enterprises / Economy	Workforce
Digital Skills	Digital Literacy Level	Digital Literacy Training
Policy and Regulatory Framework	ICT (Sector) Regulation	Information Society Strategies and Policies
Content and Services	Availability	Intensity of Use

1b) *Infrastructures, Affordability*: the relationship of the cost of provision or acquisition of such infrastructures in relationship with one individual or community's economic power.

2) ICT Sector: Economic sector related with the provision of ICT Infrastructures

2a) *ICT Sector, Enterprises / Economy*: Existence of firms whose activities can be comprised in the definition of the ICT sector.

2b) *ICT Sector, Workforce*: Skilled employees that work or are related with the ICT Sector and its activities .

3) Digital Skills: Skills related with both the use of electronic devices and the use of information in digital format

3a) *Digital Skills, Digital Literacy Level*: The measured levels of such skills in an individual or a community, both in number of literate people and degree of their literacy.

3b) *Digital Skills, Digital Literacy Training*: The existence of courses, curricula or other training plans to increase the Digital Literacy Level.

4) Policy and Regulatory Framework: Whether there are explicit rules, laws, policies, etc. that directly affect and try to put in order the Digital Economy.

4a) *Policy and Regulatory Framework, ICT (Sector) Regulation*: Rules created by the Legislative branch or other regulatory bodies to regulate the Digital Economy, especially the ICT Sector and its activities.

4b) *Policy and Regulatory Framework, Information Society Strategies and Policies*: Policies, strategic plans, etc. created by the Executive branch or other governments to frame their Digital Economy related policies.

5) Content and Services: Contents and services in digital form.

5a) *Content and Services, Availability*: The existence of such contents and services, including the ones arising from the private sector (for or without profit) and the public sector.

5b) *Content and Services, Intensity of Use*: The use of such content, measured both quantitatively and qualitatively.

TABLE III
NUMBER OF INDICATORS PER CATEGORY

Name	# C	# S	1a	1b	2a	2b	3a	3b	4a	4b	5a	5b	ND	Σ
African ICT e-Index	16	6	8	1								5	3	17
ArCo	86	1	1						1			1	5	8
Basic Knowledge Economy Scorecard	140	14	2									1	11	14
Broadband Performance Index	28	1	4	3			1		1		1	8		18
Comprehensive Metric	0	1	3	3	1		2	1	1	2	3	3	8	27
Connectivity Scorecard - Efficiency and Resource Driven Economies	25	2	10					1			4	7	2	23
Connectivity Scorecard - Innovation Driven Economies	25	2	9			1	1	2			3	11		27
Core ICT Indicators	0	1	18	1	3	1		8			4	9	4	48
Core ICT Indicators for the ECA region	53	1	24	1	4	1	1	5	2		14	3	7	62
Core ICT Indicators for the ESCWA region	13	1	18	4	2	1	1	4		2	9	1	1	43
Digital Access Index	146	1	4	1								1	2	8
Digital Divide Index (DiDix)	25	6										3		3
Digital Divide Index (DDI)	191	9	9								1	4	6	20
Digital Opportunity Index	181	2	8	2								1		11
Digital Planet	75	7	2		2						15	1	3	23
E-Commerce Readiness Assessment Guide	0	1	22	6	8		1	8	28	8	5	7	13	106
E-Commerce Readiness in East Asian APEC Economies	10	1	6	1	3				2		2		39	53
e-Government Readiness Index	192	6	4								1	1	2	8
e-Participation Index	192	6									2	1		3
e-Readiness Guide	0	1												
e-Readiness Rankings	70	8	5	1			2		3	1	9	1	15	37
European Information Society Statistics	27	6	30	1	8	3	7	1			15	23		88
Freedom on the Net Index	15	1							19					19
Global Action Plan for Electronic Commerce	0	1												
Global E-Readiness	53	2	1	1	3		2	2	5	3	1		1	19
Global Internet Filtering	40	1	1						6			1	5	13
ICT at a Glance Tables	207	7	8	4	3				5	1	2	2	7	32
ICT Development Index	154	2	7									1	3	11
ICT Diffusion Index	180	3	4	1								1	2	8
ICT Opportunity Index	183	3	5									2	3	10
Index of Knowledge Societies	40	1	2									1	12	15
Information Society Index	53	13	7		1						3		4	15
Knowledge Economy Index	140	15	5	1	2	1		1			2	3	68	83
Knowledge Index	140	14	5	1	2	1		1			2	3	56	71
Layers, Sectors and Areas of the Information Society	0	1												
Models of Access	0	1												
Networked Readiness Index	134	7	9	7	5			1	2	4	3	6	30	67
OECD Key ICT Indicators	32	17	8		10	2					1	2		23
PISA	40	4					32	10						42
Readiness for the Networked World. A Guide for Developing Countries	0	1	4	1	2	1		2	1	1	5	2		19
Readiness Guide for Living in the Networked World	0	1	9					3	2	1	6	2		23
Real Access Criteria	0	1												
SIBIS Framework	17	1	25	1	1	1	22	12	8		20	38	5	133
SIMBA Model	8	1	9	3	1	1			7	3	4	2	24	54
Sustainable ICT Framework	1	1	9		2	3	1	1	2	6	5		11	40
Technology Achievement Index	72	1		2		1			1				4	8
The Access Rainbow	0	1												
The CTO Guide to the ICT	54	3	9	6	1				12	2		2	10	42
The Development Dynamic	0	1												
The eInclusion Index	0	1	1				1				1	1		4
The Global Diffusion of the Internet	25	4	5					1	1		2	4		13
WDI Key ICT Indicators	211	7	3									1	2	6
World Development Indicators – The information Age	153	14	2	2							3	1	2	10
World Telecommunication ICT Indicators	209	34	41	20	15	6			1			30	6	119
World Telecommunication Regulatory DB	191	11							32					32
TOTAL			366	75	79	24	74	63	142	34	148	197	376	1578

#C: number of countries; #S: number of time series. Categories correspond to those of section II.B; ND: nondigital

C. *Counting the indicators*

When possible, we counted the number of indicators introduced in each model (see Table III). Two calculations were performed with them:

a) Distribution according to the categories that the respective authors had defined in their original models.

b) Distribution by the primary categories of the model that we introduced in Table II - which we call the simplified model

c) Distribution by the secondary categories of our model - which we call the extended model or the Comprehensive 360º Digital Framework

Additionally, we included a new category to the simplified model that we called "Nondigital", whose purpose is to collect the "digital noise" introduced in the model. This category gathered the indicators that were not directly related to the Digital Economy or, in other words, which did not strictly belong to any of the other primary categories (e.g. the GDP).

Table III provides the distribution of indicators for each analyzed model according to our Digital Comprehensive 360º Digital Framework, including the nondigital indicators.

III. Distribution along Primary Categories

The next four figures show the share of each category in the total distribution of indicators; that is, how the 1578 indicators analyzed are distributed along the categories we defined in section II (in this section using the primary categories and in the following section using the secondary categories). The shares are presented with and without taking into account "nondigital" indicators (e.g. Population).

A caveat should be made about these – and the subsequent– figures showing the distribution of the amount of indicators in each model: what we are here performing is a rough distribution of these indicators without taking into account what they represent. Thus, the count of indicators might not, sometimes, be an accurate approximation. For instance, a hypothetical index might be composed by five indicators: desktops per person, laptops per person, computers (total) per person, number of e-Books available in local language, and number of e-Business transactions per person. In this case, Infrastructures category would have three indicators vs. two belonging to Content and Services. However, the reader will agree that the Content and Services category would be more representative of the reality than the one depicting Infrastructures, whose indicators are rather redundant and could be summed up in but a single indicator: computers.

Back to our analysis, the first thing we notice when looking at the data is that infrastructures generally tend to be overrepresented in comparison to other types of indicators, especially those related to the users themselves and how they interact with the Infrastructure (through the ICT Sector) and the digital Content and Services (through the Policy and Regulatory Framework). Moreover, Content and Services closely follow Infrastructure indicators in the final proportion of indicators, though they mostly measure the measurement of the intensity of usage of the aforementioned Infrastructures.

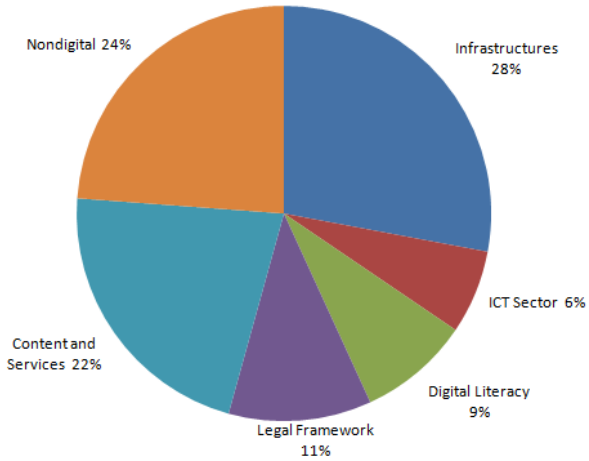

Fig. 1. Distribution of the primary categories – including nondigital indicators

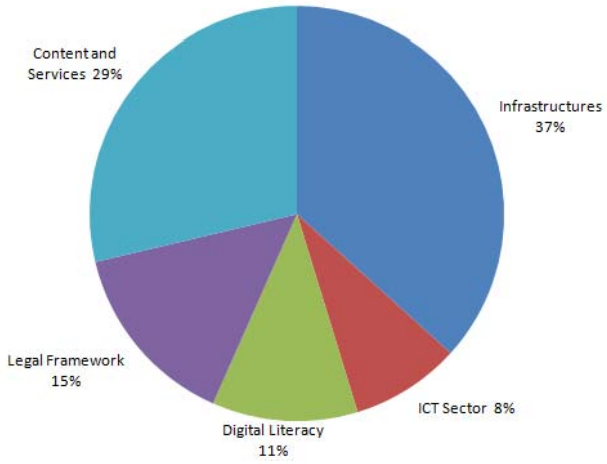

Fig. 2. Distribution of the primary categories – excluding nondigital indicators

Given the fact that most measurement tools have been developed by institutions serving policy makers and decision takers, it is surprising to see intermediate enablers of the Digital Economy – a strong ICT sector, human capital in the form of digital literacy and an appropriate policy and regulatory frameworks – having but about one third of the total "attention" span of the models that describe the Digital Economy.

Thus, it seems that what is being measured is the way in which the appropriate infrastructures and capital are transformed into actual use, ignoring the black box of how

this transformation takes place. Or, in other words, that most measuring effort is put in measuring Infrastructures and their saturation, setting aside why and how this happens.

This lack of available indicators makes more difficult measuring the reasons of success or failure, not to mention the fact of making appropriate decisions given a state of the question, the goals to be achieved and the resources at hand.

On a more qualitative level – hence not shown in the previous figures but seeable on a thorough analysis of the indicators we chose –, it is puzzling to realize that within the category of Infrastructures, almost no software is taken into account. True, some indicators measure software, specially its use or purpose of use (e.g. educational software), and sometimes affordability; but while hardware and connectivity are always present, software is usually not. This void is surprising at least for two reasons. First, because free/libre open source software has become a sociological issue important enough to deserve measuring. Second, because software is a crucial and unavoidable part of infrastructures and, in many countries, a matter of concern because of costs, security issues or its power to develop an e-services focused industry, to name a few strategic facts.

Regarding Content and Services – and as it happened with software – almost all measuring efforts have been put in digital services and not in content at all. Though it could be argued that many measures about, for instance, e-Government do gather a direct or an indirect measure about content, it could be equally argued that is content is but a part of public services, a means to perform a transaction. But content, an increasingly major commodity, is quite often left out of the equation, even if the entertainment and media industry are creating powerful corporations due to the increasingly importance of their invoicing and revenue. Again, content in local language has become a crucial aspect in most debates about the role of ICTs in spreading knowledge, thus why our surprise in finding the issue mostly uncovered.

IV. Distribution along Secondary Categories

In section II we split each primary category into two secondary categories. Our aim in doing so was to separate indicators that represent supply-side or stock variables from indicators that represent demand-side or flow variables. Although sometimes indicators do not strictly fall in either or the other category, we found it useful as the division helps in telling the difference between the status quo and trends, as the results will show.

Under to this new categorization, affordability of infrastructures showed up to be of little interest according to their representation in measuring devices. While the amount of installed capital is consistently measured and in many ways, how this infrastructures will be effectively sustained is just left aside. Economic sustainability is hence often left out of the, which is quite a worrying finding, especially when many of these infrastructures are usually designed to accelerate or to foster development, as stated in many reports and articles meant to back the different models here analyzed.

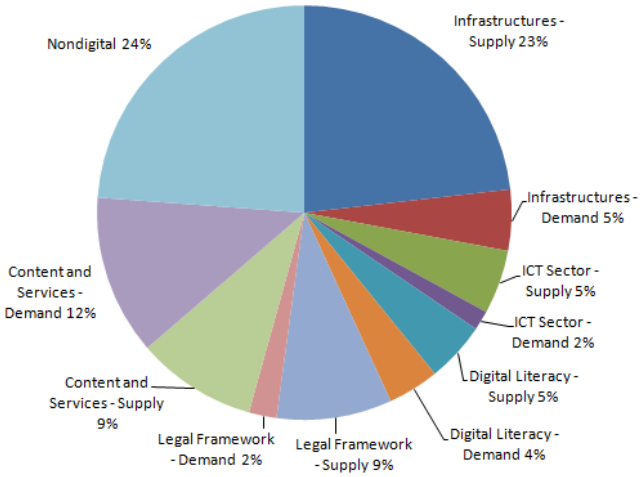

Fig. 3. Distribution of the secondary categories – including nondigital indicators

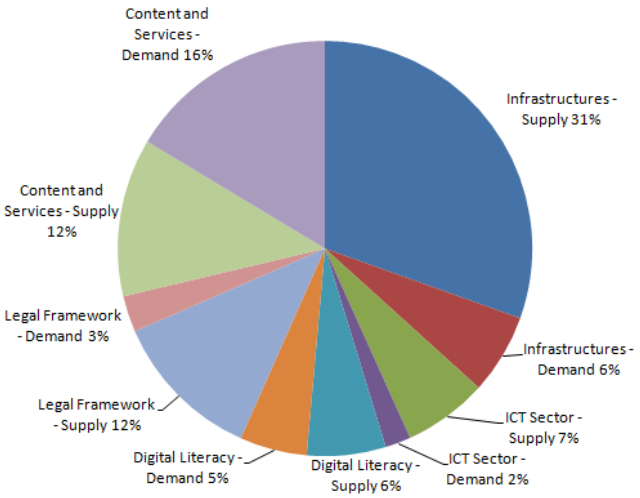

Fig. 4. Distribution of the secondary categories – excluding nondigital indicators

If the role of ICT Sector is, in our opinion, under-represented in many models – as we stated in the previous section –, the more dynamic part of this industry – human capital capacitated with the appropriate digital competences – is virtually forgotten. If, as we believe, the availability of trained human capital is a crucial asset for some countries to leverage the power of ICTs for development, in our opinion it does not make any sense not to be measuring the quantity, flexibility, knowledge levels, etc. of this professionals.

In line with the previous arguments, it is shocking to find out how little effort is put into measuring the digital competence of the population at large. And by "at large" we are not meaning end users who use – or do not use – the available technologies, but also the political leaders and economy rulers which are supposed to be the drivers of change and progress.

Finally, a major concern are the very few existing indicators that measure both the regulation of the Information Society in general and, specifically, existing policies to promote it. The comparison is not only difficult - but achievable - but a quantitative analysis of the effects of policies and regulatory framework in the development of the digital economy is virtually impossible. And if you wait for policies that have measurable results that are effective and efficient, the lack of indicators in this regard is dismal.

Last, a major concern is in how few existing indicators measure both the regulation of the Information Society in general and, specifically, the existing policies set up to foster it. Not only benchmarking is difficult to be achieved, but also quantitative analysis on the effects of policies and regulation on the development of the Digital Economy, which becomes virtually impossible. And if policies (in general) are supposed to be measured for performance, effectiveness and efficiency, the lack of this kind of indicators is, to say the least, worrying.

V. Distribution along categories and along models and time

If we look separately at how indicators are distributed over the categories in descriptive models, theoretical models, composite indices and data sets updated regularly, what we see is that there are no major differences in the distribution of aggregates of categories between descriptive and theoretical models and more applied, the only difference being a lower proportion of Content and Services Infrastructure + in most theoretical models regarding the applied (59% versus 63% in both cases applied). That is, in our opinion, once again surprising, since one would argue that the main barriers to go from theory to practice would be to define appropriate indicators to measure the desired variables ... and get the best data for these indicators. We see, however, that most theoretical models are too conservative in their ambitions or even do not pay on the ropes the availability of real indicators, which are self-limiting and adapting ex-ante to what practical application could provide .

When looking separately at how indicators are distributed along categories in descriptive models, theoretical models, composite indices and data sets updated periodically, what we see is that there are no big differences in the distribution of aggregate categories between conceptual and practical models, being only slightly lower the share of Infrastructures + Content-and-Services in theoretical models than in applied ones (59% vs. 63% respectively). This is, to our understanding, an unpredicted finding, as one would expect conceptual models to be more “pure” or “challenging” – in the sense of demanding what is needed to be measured – while one would find applied models being built up according not to what is needed but according to what is at hand. In other words, we would be expecting a shift from theory to practice followed by a shift from the appropriate indicators for the desired variables to be measured to indicators based on what data is just available to feed them. A possible reason to explain these conservative models – that is, models that do not challenge the availability of actual indicators – is that they are adapted ex-ante to what a hypothetical practice could provide, thus transposing the limitations of data harvesting to proper theoretical modelling.

The appearance of new models along time just reinforces this last finding, which, if our stated reasons are true, is a biased outcome of the dependence of scientists and theorists from data providers and survey designers and promoters.

VI. Distribution between supply and demand

Even if our distinction between supply- and demand-side indicators was arguable – which most probably is – the absolute and overwhelming predominance of the indicators on supply poses little question on what parts of the economical analysis are less analyzed. Indeed, if we revisit what was stated in section III about the nature of the indicators featured in the Content and Services category, the unbalance between supply- and demand-side indicators is even greater.

Indeed, many of these demand-side indicators are closely related to the extent of the use, not the intensity or the kind of usage. Thus, the effective usage (understood as qualitative usage vs. the quantitative usage usually measured), the different kinds of usage, the different levels of adoption of certain technologies and services, etc. Remain mostly uncovered by these measuring devices, hence the demand side being even more neglected than it might seem at first sight, a relevant finding especially taking into account how effective for development have proved to be in the past policies to stimulate demand [15].

Moreover, and given the growing interest in user-generated content [25] – a 100% demand phenomenon – measuring instruments seem to be lagging behind on the current interest of society, researchers, policy makers ... and the content industry itself. As we have been seeing in previous sections, this imbalance is again not particular to any specific model – even if some models are more balanced than others – but a general feature of all models tested.

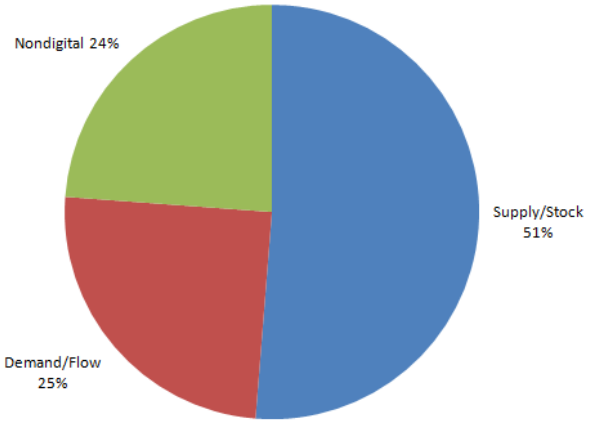

Fig. 5. Distribution of the primary categories – including nondigital indicators

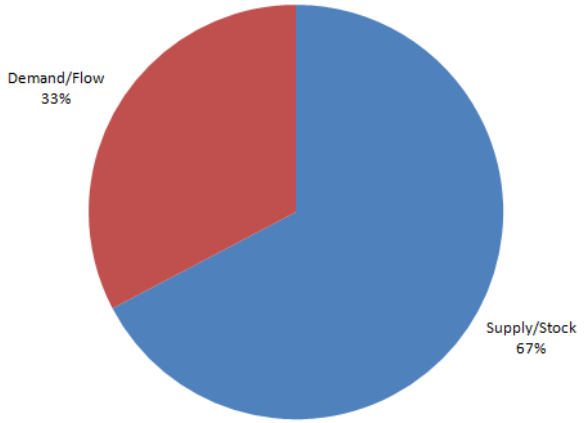

Fig. 6. Distribution of the primary categories – excluding nondigital indicators

VII. On the Quality of the Measuring Tools

When we look not at the aggregate but at the disaggregate level, two main observations are to be made.

The first one is about the scarcity of broad time series in terms of number of variables covered by the respective number of indicators. Despite – or added to – the fact that ICTs are quite recent – especially if we take year 0 circa 1994-1995 with the hatching out of the World Wide Web for the general public –, quality or more complete series do not last longer than five or six years with counted exceptions. Even in these cases, it is likely to be found that they are – as usual – focused on infrastructures, being usage and other more subtle variables just not kept into the measuring loop.

The second one is the number of countries for which these data are available. Lack of awareness of country leaders and lack of resources to carry on the appropriate surveys are among the main reasons attributed to this lack of data. This fact generates, at its turn, a vicious circle, where analyses are only performed for countries or variables with available data, and data is made available for countries or variables that are taken into account in cross-country analysis.

When presenting all Digital Economy models and the number of indicators they collect as a whole, it is quite evident that the by the ICT Indicators of the International Telecommunication Union [18]-[20] are the strongest at measuring everything related to Infrastructures and the ICT Sector, being the data sources from EuroStat [11]-[13], the OECD [27] or the World Economic Forum [7] good second bests – though each of them with their own limitations, especially in the number of countries covered.

Digital Literacy is proficiently covered by SIBIS [33] and OECD's PISA survey [26], but again, they only measure but a little fraction of the whole world – and, indeed, SIBIS was a one-time assessment that was not repeated once the project ended.

As per legal issues, the problem is again that the E-Commerce Readiness Assessment Guide [1] does not provide any data at all, even if their design might be mint. Thus, the best data set actually up-to-date and available is the EIU e-Readiness Rankings [9]-[10], the World Bank's ICT at a Glance Tables [36] and the World Economic Forum's Networked Readiness Index [7].

Finally, with regard to Content and Services, WITSA's Digital Planet [46] is surely the richest database for expenditure on the ICT sector (including all types of goods and services) as well as an excellent source of information on the supply-side if taking expenditure as a proxy. The demand-side (usage) is perfectly covered, again, by the ICT Indicators of the International Telecommunication Union. As second bests we could take into account the aforementioned Economist Intelligence Units' e-Readiness Rankings, the World Economic Forum's Networked Readiness Index or the Partnership on Measuring ICT for Development's Core ICT Indicators [29].

Outside of the strict scope of the Digital Economy, the World Bank's Knowledge Assessment Methodology [37] is probably the best option to look for an appropriate socioeconomic framework.

VIII. Conclusions

We have here seen the main strengths and weaknesses of many existing models whose aim was describe and measuring Digital Development and its many theoretical incarnations.

Many of them – if not all – rely heavily on the mindset of

the promoting institution and/or researcher, or are explicitly aimed towards measuring but one part of the different pieces that conform the Digital Economy.

We believe that it is possible – and useful too – to group them under three general labels according to the vision that they have of the concept of access. These indeed different concepts of access to digital development actually shape their inner structure as a model and the kinds and shares of indicators chosen. Inspired in Raboy's classifications [30]-[31] and Warschauer's [42], we believe there are three main frames or trends in which most of our 55 models fit:

1) The Telecommunications Model
2) The Conduit and Literacy Models
3) The Broadcasting Model

If we stop to look carefully at our categorization in Table III, the concentration of indicators in the provision of Infrastructures and their Usage is higher than in any other categories combined. A thorough analysis will show that models such as the World Telecommunication / ICT Indicators or the Core ICT Indicators are biased toward the Infrastructure and ICT sector (the left side and of the table, especially if we consider usage as saturation of infrastructures), while others are more balanced across all categories and even biased towards some of the applications (the right side of the table): the e-Readiness Rankings, the Networked Readiness Index or the Readiness guides [4], [6], [14].

It is noticeable too that some initiatives born with a strong "for development" focus are amongst the most balanced ones in the whole set: for instance, the European Information Society Statistics were created within the eEurope 2005 and i2010 frameworks [11]-[13], which are especially aimed at fostering the Information Society in the European Union as a tool for inclusion. A similar thing happens with the SIBIS Framework [33], a European Commission funded project belonging to the European Sixth Framework Program's Information Society Programme; the SIMBA Model [44] and the Sustainable ICT Framework [34], both belonging to the KaU framework and KTH strategy and absolutely focused to developing countries; and even under the umbrella of the technology biased Core ICT Indicators [29], both the ECA and ESCWA [8] adaptations do have this trend towards a more balanced approach. On a more conceptual approach, we can mention Barzilai-Nahon's Comprehensive model [2], a theoretical one that has achieved a good balance too, thus mirroring the commitment of the author with development.

In the position to promote the use of ICTs among the population to achieve higher quotas of progress, in general, and in the field of developing countries, in particular, then clearly we need a more comprehensive model, one that collect the sensitivities and needs and, above all, the aspects that define a digital economy that could propel the country towards the Information Society.

Our overall conclusion is that fostering Digital Development to achieve, or leveraging Information and Communication Technologies for Development does require better models to define and measure the digital landscape. We believe that a more comprehensive model – like the comprehensive 360º digital framework that we presented in Table II and that we used in our analysis – is needed for policy-makers and decision-takers to gather all sensibilities and aspects that define a Digital Economy. Only with such a model we believe that appropriate measuring will be possible and, thus, correctly assess the impact of policies aimed at fostering Digital Development.

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