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

Philosophiae Doctor (PhD) Thesis

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Supervised by Tim Kelly

Information and Knowledge Society
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Introduction

1. Introduction

Over the last 250 years or so, the Industrial Revolution and its effects have defined and shaped the World as we know it (Mokyr, 1997; 2000). Around one-third of the World's population have achieved undreamed of levels of prosperity. A further third are beginning to benefit from at least a basic level of welfare and the provision of services such as education, healthcare and housing. But the remaining one-third have not yet seen the benefits of the Industrial Revolution and, in the worst-case scenario, may even be a casualty of the trends that are benefitting the richest segment of society.

Now, a new revolution – the Digital Revolution – is again reshaping the World and is promising to overcome at least some of the disadvantages of place and time that marked the Industrial Revolution (Zysman & Newman, 2006). With the appearance of computers during the second half of the 20th century, the development of personal computers in the early 1980s, and the boom caused by the opening to the public of the Internet and mobile telephony during the last decade of the XXth century, the debate about the impact of Information and Communication Technologies (ICTs) has quickly heated up. One reason for the current debate is quite simple: if we are really living through a revolution, shouldn't we be doing something about it?

If it is indeed a revolution (Greenwood, 1999), then we are arguably only living through the very first stages, and that makes it difficult to understand the effects that are now happening, or are about to come. Furthermore, all countries face a challenge in understanding the causes of these effects, which are at best only blurry, and in attempting to master the Digital Revolution. If the Industrial Revolution caught many by surprise, no one can be excused for missing the latest train heading towards socioeconomic development (Boas et al., 2005). For this reason, there is a huge and urgent interest in measuring the impact of the Digital Revolution *before* it fully materializes (WSIS Executive Secretariat, 2002-2006).

The impact of the Digital Revolution has been observed by many authors in matters of productivity, competitiveness and other issues related to the survival of individual firms or the hegemony of a national sector in the international economic arena. But some authors also point at the fact that the impact of the Digital Revolution might cause countries to swap positions, with some being able to "leapfrog" development while others are in danger of missing this new train of progress.

The identification of the key factors that are likely to shape this revolution and the capability to measure them – both *ex ante* and *ex post* – would enable policy-makers and decision-takers to

a) Decide, according to the importance of the expected changes, how to intervene, and at what level; and
b) Determine how to measure the success of this allocation of resources.

But insofar as the outcomes of the Digital Revolution are still messy and blurry, then the same is true of its approaches, interpretations and models. Concepts like access, the lack of it, the digital divide, Information and Communication Technologies for Development (ICT4D), the tools that measure access or the impact of ICT4D or e-Readiness, to name but a few, have become a cloud of misunderstandings on a road that is paved with good intentions.

1.1. Goals

With this work, our aim is to analyze how and why the different approaches to model and measure the Information Society have determined what is meant by the concept of access to Information and Communication Technologies and digital development. And, based on this first analysis, work on and propose a 360º digital framework that can serve policy-making while, at the same time, be able to state whether and why governments should seek to foster the development of the Information Society.

Our approach is, necessarily, a multidisciplinary one, as our comprehensive approach to measuring the digital economy and its impact will imply working across several disciplines, including Economics, Political Science, Sociology, Law and Computer Science.

In this sense, it is also worth clarifying that we are not focusing on knowledge and its role in the economy, the society or personal identity, but in what enables knowledge to play this role: ICTs or, in other words, the transition from analogue to digital technologies. This is why we will be talking in general about the Digital Economy, and will also be using (almost) interchangeably concepts like Information Society, Knowledge driven Societies or Network Society, without entering in their differences.

On the other hand, and following the rationale of enablers, our intention in this work is not so much to measure the impact or the application of knowledge, but rather to measure how ready societies are to benefit from its use. Thus, we are focusing in the tools as sources, not in the targets or results of their application.

That being said, the goal of this research is to identify the relevant factors that promote digital development, to define and describe – on that basis – its different stages and to explain the causes why a particular country might therefore be classified as a digital leader or a laggard and, lastly, answer whether and why governments should foster the Information Society.

To address this goal we have split our research into three main areas:

- Clarification of concepts and their importance;
- Analyzing the available tools for measuring the digital economy; and
- Defining the stages of digital development, their characteristics and their causes; in particular, isolating the role of the public sector.

In the first area of research we cover the impact of ICTs, the concepts of access and the digital divide and the need to foster digital development. Our research questions in this area are:

- What is "access"? What are its components?
- What are the main approaches to defining access and why?
- Is there any evidence that access to ICTs has had a positive or negative impact on the general socio-economic development of a country?
- Why may there be a lack of access in a particular country or region, or to use a more familiar term, a "digital divide"?
- Is it worthwhile for governments to attempt to foster digital development to accelerate the positive impacts of access to ICTs?

The second research theme explores, broadly and in depth, the ways in which access, digital development and the digital divide have been measured over the years, in particular through the use of composite indices. The related research questions are as follows:

- What are the main models that depict digital development?
- What are the approaches that these models follow to describe digital development?
- What are the consequences of the different approaches followed in defining digital development models?

The third and final research theme focuses on the different stages, or phases, of digital development, their main characteristics and the reasons why digital development at the country level might be unevenly distributed.

- Can we group countries according to their different levels of digital development and thus define a comprehensive model for measuring it?
- What are the characteristics that enable us to cluster together countries according to their specific level of digital development?
- What are the characteristics that distinguish between different levels of digital development?
- Why some countries are more digitally developed than others?

The findings and reflections arising from these research questions should enable us to test the general hypothesis that guides our research. We believe that narrow institutional interests and a lack of appropriate data have led to a biased or fragmented measurement of digital development that is often focused on specific purposes. But if digital development is conceived as a continuum and described by means of a comprehensive model, then, at the country level, it can be observed that digital development happens in stages. These stages can be characterized by common features and distinguished by the scores achieved on certain key indicators. The improvement of its general economic indicators – such as income and wealth – characterizes the progression of a country along this continuum depends mainly on. Besides these basic economic aspects, if there is an appropriate Economic Incentive Regime, strong Government prioritization of ICT and a high importance afforded to ICTs in the Government's vision of the future, then digital development is much more likely to happen. In some cases, these policies may allow leapfrogging so that a country can progress faster in its digital development than would be predicted by its general level of economic development.

Thus, our general hypothesis can be stated as follows:

- Institutional interests and lack of data lead to fragmented models to measure digital development that distort policy design. A comprehensive framework would improve such models and indicate in what ways the adoption of public policies would lead to higher stages of digital development.

This general hypothesis can be split into different partial or working hypotheses that make the research easier to approach.

Firstly, we want to highlight the fact that most approaches to modelling the digital economy and to measuring it have been biased either in their theoretical approach or in their practical implementation. We believe that several factors – such as the unavailability of data, the natural lack of definition of an emerging phenomenon, or specific interests in targeting narrower realities – have implied a complex landscape where comprehensiveness of measuring tools is still an issue.

The non-availability of data, lack of a solid theoretical framework or a focus on measuring specific measuring goals and targets have given existing models of digital development imperfect designs. Consequently, these models have evolved into incomplete, biased or fragmented models of the Information Society and there is a lack of consensus around concepts like Access, the Digital Divide and e-Readiness, despite – or perhaps simply because of – the constant evolution of these concepts.

In other words, our first working hypothesis is that

- A lack of quality data leads to fragmented models of digital development that make it both difficult to measure policies that foster the Information Society and to measure the impact of those policies on digital development, an implication being that these policies could have a better design either by focusing on filling conceptual voids or including feedback from better measurement.

Secondly, we think, nevertheless, that despite the existing problems in collecting data or the legitimate institutional interests in focusing on just a part of the digital economy, it should be possible to produce a comprehensive model, especially when targeted at policy-makers and decision-takers that have to deal with complex information and a broader sphere of intervention.

By contrast with other approaches, we think that this comprehensiveness can be reached with a combination of qualitative and quantitative tools in an iterative exercise. On the one hand, by overlapping the existing models so that there is an exhaustive inclusion of all possible approaches. On the other hand, by calculating and testing whether this comprehensive approach is statistically significant.

The growing availability of ICT indicators now means it is feasible to draw up a comprehensive framework that would combine all perspectives and approaches. Thus, it is possible to establish a middle ground among the various models on the best way of modelling and measuring digital development, despite the narrow

institutional interests of those involved in this enterprise and/or the cost of putting such a model into practice

After this consideration, our second working hypothesis reads as follows:

- A 360º digital framework approach shows that Infrastructure – Availability and Affordability –, the ICT Sector – the Industry and the skilled Workforce –, Digital Literacy – the level of Digital Literacy and Digital Literacy Training –, the Policy and Regulatory Framework – Regulation and Policies – and Content and Services – Availability and Intensity of Usage – are the key components of digital development and such a comprehensive framework for analysis could be applied in policy design.

If we can draw a comprehensive model, it is that we expect countries to reach different levels of digital development, and this progress can be measured using the tool described above, which we have termed the "360°digital framework". We believe that we can describe these levels or stages of digital development and, more important, that it is possible to explain why some countries reach higher levels while other countries appear stuck at lower ones.

Indeed, we want to go one step beyond and state that governments have an important responsibility – and, hence, a commitment – in their respective countries to achieving a specific stage of digital development.

Our third working hypothesis is that

- Higher levels of wealth and economic development, education and the existence of digital infrastructures almost always coincide with higher levels of digital development. Nevertheless, Governments can accelerate the process of digital development through the adoption of public policies that frame and foster the Information Society – such as Government prioritization of ICT and assigning a high importance to ICT in government vision of the future – and establishing an appropriate Economic Incentive Regime. This will raise the probability of a country of reaching higher stages of digital development.

That said, we will mainly avoid dealing with the issue of leapfroggers in our work. Although this is a very interesting case of digital development, our main focus – the "mainstream" stages of digital development and policy-making – and lack of data – that would provide poor significance for this small number of countries – make it difficult to make strong statements about these group of countries, whose main characteristic is using the ICT Sector as a locomotive for development, although with unequal strategies and impact in the domestic economy.

1.2. Methodology and Structure of this Work

To verify these hypotheses we have gone through three different research stages – that correspond to the three parts of this work – moving from theory to practice, and from a qualitative methodology to a quantitative one.

Part I – chapters 2 and 3 – deals with Access to Information and Communication Technologies and their impact.

This part, mainly based on an extensive literature review, highlights what are the main approaches to the phenomenon of the digital revolution and impact of ICTs in the economy and other aspects of life, what are the different meanings given to the concept of access and whether and why should the lack of access (or digital divide) be fought.

Chapter 2 briefly highlights the major impact of ICTs in several aspects of life like the economy, work, the communication sphere, culture, engagement and empowerment, or politics and governance. It also presents some reasons why ICTs have generated a discussion around them being a tool to foster development – "ICT4D" – which is now a discipline in its own right.

Chapter 3 is centred on the concept of access. It explores the main approaches to its definition and how these approaches have influenced the debate around the lack of access – the Digital Divide – and whether it is widening or narrowing over time, and, if so, why and how. The chapter ends dealing with the importance of fostering access to achieve higher levels of development, especially in the poorest communities and countries.

Part II – chapters 4 to 10 – presents a qualitative analysis of some 55 different models of digital development (including composite indices) that have been defined, applied and or/used to describe and measure digital development.

The qualitative analysis performs an iterative study of the aforementioned models according to a specific structure of 5 categories with 2 subcategories each:

- Infrastructures: Availability, Affordability;
- The ICT Sector: Enterprises and Industry, Workforce;
- Digital Skills: Digital Literacy Level, Digital Literacy Training;
- The Policy and Regulatory Framework: ICT Sector Regulation, Information Society Strategies and Policies;
- Content and Services: Diversity and Choice, Intensity of Use.

For each model, a description and brief history is provided, accompanied by its performance on these categories and subcategories. A final review is made for each of them, identifying their strengths and weaknesses in the light of the purpose for which they were designed and in relationship with our goal to provide a comprehensive approach to measuring the digital economy.

Chapter 4 describes the qualitative methodology followed to perform such analysis, a recurrent iterative methodology that has built a framework based on the analysis of the 55 models, and analyzes the models according to that framework.

Chapters 5 to 8 list the four categories of models in which we have grouped the analyzed approaches:

- Descriptive Models (Chapter 5),
- Theoretical Models (Chapter 6),
- Indices (Chapter 7), and
- Sets of Indicators (Chapter 8).

The analyses include a brief description of the origin of the models, the main publications or places where they can be accessed, their categorized components and a final analysis of their strengths, weaknesses and suitability for the purposes for which they were intended.

Chapter 9 presents an analytical comparison of all the models, the way they were designed, and the elements that they have in common or that differ amongst them. We end up by revisiting the concept of access and to see how it has evolved according to how it is measured.

Chapter 10 closes Part II and draws some preliminary conclusions, which give rise to a proposal for a middle ground among the models by means of a tool ("the 360° digital framework") that arises from the combination of the models studied in this work.

Part III – chapters 11 to 14 – gathers all the quantitative analyses performed with statistical calculations and tests, and puts into practice the 360° digital framework and describes the characteristics and determinants of digital development.

The quantitative analyses are made at the country level with two country datasets. The first dataset is a larger one including 75 developed and developing countries belonging to the World Information Technology and Services Alliance (WITSA), and a second one with 28 countries belonging to the OECD. Some 156 indicators were extracted from 15 different databases and used to build the variables in our analyses.

The complexity of data was reduced using cluster analysis, which, in turn, also served to describe different stages of digital development by grouping countries that have small Euclidean distances amongst them and bigger ones in relationship with other countries, which can be reconstituted into other groups.

These derived clusters – or stages of digital development – were characterized by means of contingency tables – or cross tabulations – thus providing interesting insights about what constitutes a specific stage of digital development in terms of both digital and analogue variables.

Finally, logistic regressions were calculated using the clusters to find out what were the variables that determined (a) being a digital leader and (b) being a digital laggard.

Chapter 11 describes the quantitative methodology followed in the statistical part of this research, lists the sources of data and the tests applied to them.

Chapter 12 defines clusters of countries – based on the World Information Technology and Services Alliance (WITSA) set of countries – according to the selected indicators of chapter 11, each chapter being a different stage of digital development. In this chapter, clusters and categories are also described and characterized according to the factors they have in common.

Chapter 13 repeats the operations in chapter 12 applied to a subset of countries belonging to the Organisation for Economic Cooperation and Development (OECD).

Chapter 14 builds and calculates binary logistic regressions to suggest the determinants of digital development. The relationships of causality are listed and explained.

Chapter 15 features the conclusions, where we will revisit our research questions and hypotheses, while trying to find answers for the former and arguments to test the validity – or failure to validate – of the latter.

After Chapter 15, the references used in this work and other works consulted are listed in a Bibliography, followed by a glossary of authors and the corresponding annexes.

Concluding remarks

15. Conclusions

In the following pages it is our aim to summarize the preceding chapters, and to do so in order to answer our research questions and confirm (or refute) the hypotheses we stated in the Introduction and that guided our research.

In general, we can state that we can define access in a broader sense than just access to infrastructure, but including five large categories: Infrastructures, the ICT Sector, Digital Literacy, the Legal Framework and Usage (Digital Content and Services). This definition is backed by evidence as several statistically significant stages of digital development can be derived from them. From within these digital development stages, we can infer a continuous evolution with similar characteristics where stages – we identified three of them – only differ in the degree of development of the constituent variables while, on the other hand, there is a fourth group – leapfroggers – that show a quite different behaviour. This digital development is strongly determined by the role of governments in both setting an enabling economic environment and actively fostering the Information Society, among other issues like national income, inequality, health, urban population or mobile telephony.

15.1. Impact of ICTs and matters of access

In recent years, and most especially since the popularization of the Internet after the release of the graphical web browser during the early 1990s and with the increasing pervasiveness of mobile telephony, the debate over whether Information and Communication Technologies (ICTs) were causing a big impact in our lives has gained enormous momentum.

There is already a wide acknowledgement that there is an ongoing digital revolution, which might be considered as either a Third Industrial Revolution or the Third Revolution on its own, following the Agricultural Revolution of the Neolithic and the Industrial Revolution. Revolution or not – wide acknowledgement does not necessarily imply total consensus – evidence of a deep transformation due to the invasion of ICTs into all aspects of society and the economy is but increasing. This is characterized, for instance, in changes in how goods and services are produced, turning points in the international and national legal systems worldwide, redefinitions of how people socialize and understand their own identities, reconceptualizations of the provision of public goods (including intangible ones like culture or intellectual property), etc.

At the economic level we now have evidence of the positive impacts of ICTs on growth, the behaviour of markets, investment, efficiency, innovation, productivity, trade, employment and the demand-side of the economy, to name a few and at an aggregate level. Although not uniformly positive, there have been deep changes also

in how the Economy at large works: production functions, competition, new niches and obsolete business models, transformations in employment and the job arena, or access to finance.

Outside of the economic sphere, we have seen and are witnessing changes in Education, in how people socialize and communicate, in broadcasting, in self-awareness and identity building, in health provision and the health system, of the ways in which citizens are empowered and participate, in Government, governance, politics and democracy, in Justice and Law; of the impact on the environment or on culture and daily life.

And although the debate is still open over whether these transformations will shift societies towards new stages of development and welfare, or whether they will be a matter of preserving or losing the present status against increasing competition, the prevailing sense is that there is no choice but to ride the wave of change.

This debate, though generalized (almost) all over the World, has been of especial relevance when framed in the reality of developing countries. A major summit (the World Summit on the Information Society) and dozens of other meetings and reports have been espousing the benefits of the digital revolution and warning of the costs of the digital divide, especially the latter.

But, if the consensus was not absolute, it is nevertheless quite broad in matters of acknowledging the impact of ICTs in development. Rather, the problem is that there are several ways to understand access to ICTs and, hence, what the digital divide is.

In this work we have presented a continuum of positions that grade from mere physical access to infrastructures until effective usage of digital content and services (which requires their existence), going through the capacity or digital competences required to transform physical access to infrastructures into effective usage.

We grouped then the multiple definitions of access or the digital divide into three main approaches:

- The Telecommunications Model, focused on the emitter and its ability to send a message out. This is a model based on technology and infrastructures as they are the carriers of the message;
- The Conduit and Literacy Models, which stress the capacity building aspects and the effective abilities to use both technology and its mediated commodities;
- The e-Readiness Model, similar to the Broadcasting Model of Communication Sciences, whose approach aims to be a more comprehensive one, focusing on the receiver and their ability to get a message. Thus, the notion of access trespasses the boundaries of infrastructures and competences, and is set at a higher level where the whole socioeconomic framework is taken into account.

If we are to promote the Information Society, we then demonstrated that both approaches – in fact, the Conduit and Literacy Models are somehow embedded into the e-Readiness Model – were insufficient and led to different problems. The Telecommunications Model proved incomplete as it did not include several issues that were clearly related with digital development, thus making it difficult to measure the effective impact of specific policies in the development of the Information Society. On the other hand, the e-Readiness Model carried some "analogue noise" that made it difficult to tell whether specific evolutions in ICTs – resulting from specific public policies – were having their desired impact on the real economy.

Actually, one of the main problems when defining access is that some of its components are kept out of the equation, meaning that they will neither be present in the solutions nor will be solutions to address them proposed for the same reason.

After an extensive analysis we propose that the components of access are as follows:

- The existence of infrastructure, in three main components: hardware, software and connectivity.
- The affordability of the afore mentioned infrastructure, in the sense of the relative (to the user and their income) affordability of use as well as management and maintenance.
- An ICT Sector – the industry – that creates or installs, maintains and manages infrastructures and enables content and services creation.
- Skilled workforce that forms part of the ICT Sector at all levels, from the mere running of infrastructures to Research and Development (R&D) and the fostering of innovation.
- Digital competences or the capability to effectively use infrastructures and benefit from content and services.
- A dynamic creation of digital competences, translated into the inclusion of digital literacy in the syllabuses of (formal and informal) educational and training systems.
- The setting up and constant updating of a legal framework – including regulatory agencies – that brings legal coverage to the infrastructure, the industry and the usage of digital tools, content and services.
- A commitment from governments and public institutions to foster the Information Society, meaning strategies and projects related with the legal framework, facilitation of supply-side activities and promotion of demand-side incentives.
- A supply of content and services that is locally (economically and culturally) relevant.
- Demand for and effective usage of digital content and services, with intensity and pervasiveness.

It is the lack of these components which causes the Digital Divide. But this may have different causes and manifestations, which may include income, geography, technology, skills and education, the social context, effective usage and information and content related issues, to mention only the socio-economic factors.

Given the importance of digital development and its impact, and having identified the components of access and the panoply of manifestations of the lack of it, we pose the following question: Is it worthwhile for governments to seek to foster digital development to accelerate the positive impacts of access to ICTs?

While the point of view of some authors is that public policies intended to achieve universal access are but a form of interventionism in the economy and, hence, a disruption of the invisible hand of the market, our findings show that public policies that foster the Information Society are indeed necessary, for several reasons:

- Starting points matter: the different manifestations of the digital divide show that it strikes unevenly and especially affects certain communities, depending on aspects not strictly related with the market (e.g. gender, race) or that the market is failing to address (e.g. the rural divide).
- Multiplier effects matter: the digital divide not only fails to correct but can actually exacerbate some other market failures. There is statistical evidence that level of income and inequality in the distribution of wealth are characteristic or can even determine access to digital development.
- Time matters: even though the market could (eventually) fix some issues, the time needed to reach the solution matters, especially for those on the wrong side of the digital divide. Evidence shows that shifts are happening at unprecedented speeds.
- The framework matters: most claims to public inaction are grounded on a partial view of the concept of access, mainly centred in infrastructure. But there is statistical evidence that the economic environment and the proactive participation of governments are causes that trigger digital development.

Everything said so far takes on a new meaning with the advent of the so called Web 2.0; the participatory or social web. Coinciding with a first phase of deployment of the Information Society (based around deploying infrastructures, the creation of a new industry and basic digital skills), the Web 2.0 represents a shift towards the demand side of the market. It implies that the end-user is making more intensive usage of ICTs and is directly participating in making of the digital economy. This blurs the separate concepts of sender and receiver; it also challenges the usual conceptions of digital skills and digital literacy; and exerts new pressures on the regulatory and legal framework, pushing it into unknown territories.

Emerging forms of usage, accompanied by new technologies and platforms, shift the focus from the supply-side to the demand-side, thus requiring approaches centred on pull policies rather than push ones.

With infrastructures out of the spotlight, the definitions of access and the digital divide require review, as does the way we understand and model the digital economy and the Information Society.

15.2. Measuring and modelling the digital economy

With the aim of exploring in detail the different concepts of access, the digital divide, e-readiness or, to some extent, even the definition of digital development itself and the Information Society, we analyzed some 55 models that depict the various understandings and approaches to these subjects.

First of all, one of the goals was merely descriptive: to take a snapshot of the evolution of explicit and implicit models and measuring tools that continue to evolve over time. This mapping exercise should lead us towards a higher goal, namely to explain what we understand by digital development – what are its characteristics – and, even more useful, what are the causes or determinants of such development.

But, to do so, it is necessary to reach agreement – even if only theoretical –on what is the target of our analysis.

The qualitative part of our research included four categories of models and measuring tools:

- Descriptive Models, which list approximations to the depiction of the Information Society without – normally – entering in its main components. In any case, they remained at the descriptive level and were never put into practice;
- Theoretical Models, where scientific-like reflections lead to theoretical models that have been, at least once, tested against reality with real data;
- Composite Indices, that have been built in order to respond to specific measurement needs but whose design clearly has a theoretical background – either explicit or implicit – which is normally translated into an index that allows ranking, or grouping, amongst countries;
- Sets of Indicators, normally built without an (evident) theoretical framework and that usually arise from measurement needs for practical issues – i.e. not policy making, but as mere "neutral" tools for third party uses.

This was done, mainly, to track all the shades of grey between the most theoretical approaches to the more practical and applied ones.

These models were analyzed in the light of our own understanding of digital development and according to the components we have listed above. These

components were the result of an iterative comparison of the analyzed models plus the inclusion of other references from the scientific literature.

In general, we can state that the existing models have been shaped the way they are for two main reasons:

- Designs based on a specific and applied purpose that fits the general goals of the fostering organization, the best example being infrastructure-biased indices issued by telecoms organisations.
- Designs adapted to the availability of data, reverting to the use of proxies or soft data – in the best of cases – or the exclusion of variables – in the worst ones – potentially relevant to the subject to be measured.

But the devil is in the details.

These two different reasons have created, first of all, a great division amongst two main groupings of models:

- theoretical models – e.g. those of CSPP, Harvard, Bridges.org or SIBIS – that, due to lack of data, were never put into practice or applied just once and never repeated because of the costs of replication; and
- periodic indices – e.g. the DOI, the DAI or the IDI – and data sets that either fit the purposes of the promoters or fit the scarce availability of data.

In between, a third small group – e.g. the NRI, EIU's – have been struggling to bridge the previous groups, though they have (a) included data not strictly belonging to the digital economy (i.e. "analogue noise") and (b) included soft data that is susceptible to criticism because of its subjectivity or inaccuracy (especially in relationship with hard data).

The resulting work of these three main groupings has had some theoretical and practical implications.

First, attempts at policy evaluation have entered a vicious cycle, where what is not measured is not analyzed, and what cannot be analyzed is thus not measured. The final outcome is that, 35 year after the first publication of the ITU's *Yearbook of Statistics*, there still is a strong unbalance towards infrastructure indicators – and telecommunications in particular –versus other kinds of indicators.

This trend has indeed been reinforced by the fact that, in earlier times, the debate over access and the digital divide was concentrated in physically owning or accessing infrastructure.

And another fact that has yet strengthened the intensive usage of data about infrastructure is the relative ease with which they are measured: in comparison with

other sources of data. Measurement of this kind of infrastructure – and, sometimes, also their use – is quite straightforward and, thanks to industry standards, relatively easy to compare and aggregate.

On the other hand, if the industry is keen to measure its penetration, performance or efficiency, it is necessary to consider other aspects of the digital economy that have attracted relatively less interest or have had a much lower return on the investment in acquiring data. This is the case, of course, of data about almost everything not directly related with infrastructures or specific usage.

Thus, we find that after measuring infrastructures, usage has been the next step in measuring policies – and, implicitly, in modelling the digital economy.

As we have already shown, these two main groups of indicators – infrastructure and usage – have the biggest share of all indicators analyzed in this work, relegating to a secondary level all other aspects of digital life, such as digital literacy, the legal and policy frameworks and the availability of digital content and online services.

In brief: while monitoring has generated a wide array of tools, explanation of the reality has not. While telecoms is the main source of data, especially for commercially-important data, socioeconomic related data has been kept out of the equation for too long. Though not forever, thankfully.

Though present since the mid 1990s, in more recent years – partly due to a more qualitative and diverse usage of the Internet and its applications – a growing interest has emerged to obtain data about what makes people use technology besides infrastructures, meaning (a) motivation and (b) the framework they are in.

This has reinforced the existing e-Readiness Models – such as those of the World Economic Forum, the Economist Intelligence Unit or the World Bank, to name but a few – and new strategies to "fill in the blanks" left by telecoms.

Unfortunately, and unlike the case of infrastructures, the remaining blanks are difficult to measure using hard data, resulting in two problems.

The first one, the impossibility – real or related to cost or other issues – of obtaining such data. The second one, the option for a second best solution based in gathering soft data coming from surveys whose quality is, by far and by construction, not comparable with hard data – despite the huge and worthy efforts to improve their explanatory power.

When data has been made available, an already existing problem has reappeared with more virulence: the cost of replicating surveys and, thus, the cost of maintaining time-series data so that not only static snapshots can be taken of the reality, but also its evolution over time.

Summing up:

Cause	Consequence
Novelty of the digital revolution	Focus on infrastructure
Relative ease of extracting data on infrastructures	Unbalance in favour of data on infrastructures
Higher commercial value in acquiring telecom data	Unbalance in favour of telecom data (little "social" data)
Cost of acquiring data and continual refinement of methodologies	Lack of time series
Cost of acquiring data	Lack of broad geographic series
Cost of acquiring data	Trade-off between periodicity and breadth of measurement
Relative higher cost of extracting "social" data	Unbalance in favour of data on infrastructures
Unbalance in favour of data on infrastructures	Reinforcement of unbalance in favour of data on infrastructures due to models adapted to poor data availability
Lower quality of soft data	Reinforcement of unbalance in favour of data on infrastructures due to lower validity of soft data

Table 24: Data gathering problems

At the qualitative level, these mainly quantitative issues have implied conceptual or theoretical biases that, in our consideration, are more serious than the mere lack of availability of data or its poor quality.

Adding to the already mentioned imbalance between infrastructures and usage data, and the rest of the data categories, there is also an imbalance in supply-side vs. demand-side indicators. Far from being yet another quantitative issue, its implications are crucial because policies depend on what is measured, in part because it is what gets the attention, and in part because it is what has been made available to evaluate impact.

The prevalence of supply-side indicators means, for instance, that we are giving priority to the existence of infrastructure but leaving aside whether it is affordable for the end user. Or that we are approximating usage by measuring Internet traffic or bandwidth use, which is only an imperfect reflection of what is really happening on the demand-side and, more important, does not explain why people are motivated to use the Internet or cellular phones.

We are not saying that *all* the focus should be put on demand, but that it should at least be *as* focused as the supply-side. And this is especially important when the

supply potential is increasing – due to installation of infrastructure or creation of online services (e.g. e-Government) – and its utilization is still relatively low. Thus, demand-side measurement is required so as to understand the whole picture and be able to design appropriate policies.

The latter gains even more importance if we consider that failing to measure the reasons for usage may actually lead to some towards paths of exclusion. Not including in the model all the variables that matter will most probably cause not just a technical failure of that model, but an ethical failure of the institution fostering it: are policies promoting what really matters? Who are these governments serving?

Last, but not least, the imbalance between infrastructure + usage vs. other data categories leaves aside, once again everything in between what is to be used and the use of it, which we can call (as we did before) causes, or which we can call enablers.

Then, the unbalances and biases not only show failures under a merely quantitative point of view, but also on quality. By enablers, we understand the ICT Sector, skills and capacity building and the legal framework, including all side-effect issues such as affordability and effective usage or e-Awareness.

In our opinion, there is too little concern about the affordability of infrastructure relative to the view of residential users, for whom price is a primary issue. Added to this, their usage is not only a matter of physical access, supply of content and services, but capability – in a very broad sense – to use them. And capability is related with skills, but also with the permission to do so– again in a very broad sense –, which ranges from laws to policies to the socioeconomic environment.

At the macro level, forgetting the enablers also implies letting aside the possibilities of the (underrepresented in the indicators too) ICT Sector as a driver of development.

In other words, the actual landscape of the measurement of the digital economy is focused more in quantitative monitoring than on qualitative impact. And qualitative impact requires – as we will see later – better measuring tools so that appropriate decisions can be taken and their outcomes properly measured.

In our research, we have humbly provided a comprehensive approach, a 360º digital framework, based on our ten categories – mentioned above in this chapter as components of access – and that gathers, we believe, all the possible approaches and factors that compose the digital economy. In doing so, too, it is our purpose to propose a possible solution to the problems of both the Telecommunications Model and the Broadcasting/e-Readiness Model when applied to policy-making and decision-taking.

This aim of comprehensiveness serves the two purposes for which most measuring devices have been created, namely (1) to monitor what has been created

(infrastructures, content usage, etc. and (2) to explain the reality (how, why, etc.). On the other hand, it avoids the common misuse of these tools, especially when using monitoring tools to infer explanatory statements (e.g. by using infrastructure-centred indices to rank countries according to their digital development).

Last, with this qualitative analysis and the 360º digital framework proposal we believe we have been able to answer the first and second sets of research questions we stated in the introduction, which also imply not refuting the first two hypotheses about the incompleteness of models and measuring devices and the possibility to be holistic in the approach despite certain unavailability of data.

In other words, we can so far state the following conclusions:

- Narrow institutional interests and a lack of appropriate data have led to a biased or fragmented models of digital development that make it both difficult to measure policies that foster the Information Society and measure the impact of such policies in digital development.

- The effect of these biased models is a fundamental distrust towards the design of policies that have not tried to fill the gaps with further data coming from other sources that made it possible to fill in conceptual voids or to include feedback about the impact of such policies.

- A 360º digital framework approach should include five categories and ten subcategories so that all factors of digital development are appropriately covered: Infrastructure – Availability and Affordability –, the ICT Sector – the Industry and the skilled Workforce –, Digital Literacy – the level of Digital Literacy and Digital Literacy Training –, the Policy and Regulatory Framework – Regulation and Policies – and Content and Services – Availability and Intensity of Usage –.

15.3. Characteristics and determinants of digital development and the role of the public sector

With this 360º digital framework as a working tool, we faced the challenge to (a) test it against reality and (b) define, characterize and find the determinants of the stages of digital development.

We found that we could draw four stages of digital development where 45 countries could be allocated by calculating their Euclidean – statistically significant – distances amongst themselves. The test was repeated to find four sub-stages within the most developed ones.

The stages of digital development we defined are as follows:

1. Digital leaders: they lead digital development by scoring higher than other countries in most categories and at a very advanced level. They can be subdivided between:
    a. Primary digital leaders; and
    b. Secondary digital leaders.
2. Digital strivers: they have established a framework for digital development but still have to strive to get higher scores in most categories. Again, it is possible to subdivide between:
    a. Primary digital strivers; and
    b. Secondary digital strivers.
3. Digital laggards: though they follow a similar path as leaders and strivers, they clearly lag behind other countries – especially digital leaders – and score lower in most or all categories.
4. Digital leapfroggers: do not appear to follow the same path between the three stages as other countries; instead, they intensively foster the Information Society in a context of low income and low development in general (in relation to other more developed countries), making it likely that they are achieving some sort of development leapfrogging.

As we have just stated, one of the most interesting things in this scheme is finding out that most countries – apart from leapfroggers – behave alike and follow the spectrum of digital development, with the differences arising mainly in the degree of development of their aggregated indicators.

This common pattern we are talking about can be described as follows, keeping in mind that – at this point dealing with cluster analysis and characterization – we are talking about characteristics and not reasons of causality – dealt with later on – and that there were no time-series in our analysis.

Economic development is the fundamental characteristic of digital development. In general, developed countries are digital leaders or figure in the upper tiers of digital strivers. All in all, most aspects we can find about digital development can be intuitively inferred from this last statement.

Thus, and entering the digital scenario, infrastructures – as in the real economy – play a major role in digital development. Its quality – pervasiveness, bandwidth, etc. – is linked to digital development and, indeed, seems to draw a sort of a threshold related with other digital characteristics, especially expenditure on ICTs. In this sense, below the threshold, expenditure is high so to achieve the essential infrastructure to run the Information Society. Above this threshold, expenditure in ICTs is lower in relative terms, and the emphasis can be placed on other issues like content and services. As said, and especially amongst digital leaders and strivers, infrastructures are installed gradually along tiers but following a very similar pattern. In this respect,

investment in broadband is an increasingly strategic asset both to fuel the local market as for international relationships.

The existence of infrastructures – a quantitative indicator – also has a qualitative side: affordability. The cost of infrastructures – especially their use – seems also related with digital development and seriously drags on the further evolution of the digital economy and forces individuals and societies to increase their expenditure in ICTs, in a clear trade off with investment or consumption of other commodities, presumably reducing their welfare too.

A certain level of available infrastructure – above the threshold we mentioned before – coexists with more important roles of the ICT Sector in these economies. An ICT Sector with a twofold projection: the domestic economy and the international arena. As one of the most competitive sectors (especially at the international level), the strength of the ICT Sector is usually accompanied by high R&D levels, both in absolute terms and in relationship with other industries. When infrastructures are present and the ICT Sector is strong, R&D is the norm and is linked to the highest levels of digital development.

The ICT Sector is the most distinctive issue separating digital leaders, strivers and laggards – which follow the same pattern but at different speeds – from leapfroggers. The latter, are strongly supportive towards developing a domestic ICT Sector and putting huge effort in the investment related with digital infrastructures. Their target: the international export market. These approaches seem to be strategies on their own, regardless of the stage of development of their (analogue and digital) economies at large or the impact (beyond the direct one) on their economies and citizenry.

There are some countries – leapfroggers – that are strongly betting on the development of an ICT Sector and investing in digital infrastructures with a clear focus on the international market. This is done despite their initial allocation of resources and the impact on their economies is, at least with our data, unclear.

If we extend the concept of R&D to the human (capital) level, the presence of computers and Internet in schools is also related to digital development. Thus, the investment in human capital and improved digital literacy is also a tipping point of digital leaders and some digital strivers. This is, again, a pattern that repeats itself along the stages of digital development, fading out as we walk through the different stages. We find it characteristic that a main difference between digital leaders and strivers in opposition to digital laggards is, precisely, this support and engagement in digital competences in particular and human capital in general. Nevertheless, this is also common ground between developed and developing countries, so it can be read that, again, wealth or income, education and development are a triangle that replicates itself from the analogue to the digital world economy.

All the former aspects flower in the appropriate setting: the legal framework. ICT regulator frameworks, such as specific Telecom Acts, or intellectual property protection, go hand in hand with higher levels of installed infrastructures, ICT Sector evolution and stronger digital literacy and skills as proxied by Internet in schools. This is also related with a proper legal framework for the analogue economy, where innovation, an efficient economic incentive regime and the level of urban population seem a key to the development of the digital economy and the ICT sector at all levels.

This appropriate legal and economic framework allows the private sector to be early adopters – in relation to the public sector or households – and constitute, in most digitally developed economies, the main drivers of development at the content and services category, both in the supply-side and the demand-side. Though supply seems usually to come earlier than the demand-side within enterprises, it is quickly followed by (if we were able to speak of causality we would have said that it triggers) strong demand in the form of end user usage.

Last, and speaking of usage from the public sector, is it to note that both the two mainstream economic philosophies within capitalism – absolute laissez faire and mild Keynesianism – seem to be present (and compatible) with higher levels of digital development. Actually, if we stated that the role of the government in setting up the rules and guidelines of the digital economy was definitely tied to other digital development indicators, direct intervention – e.g. expenditure in ICTs – seem to have neither a positive nor a negative correspondence with digital development. Notwithstanding, it is also true that some of the triggered demand we talked of in the previous paragraph can also be related to the provision of public services online, as some variables (secure servers, domains) are not disaggregated per sector.

So, if these are the characteristics, what are the causes?

First of all, we have to take into account the caveat that just some coefficients fall within a 95% confidence level, being most of them close above this level, and a remaining few but within the 90% confidence level.

In digitally developed countries, causes that actually determine these economies to be labelled as digital leaders (or are at least closely associated with it) include life expectancy at birth, inequality (at 20%), urban population, the Economic Incentive Regime and Government prioritization of ICT.

Life expectancy at birth has a very small but negative impact on digital development. We can infer from the negative relationship between digital development and life expectancy (more life expectancy, less digital development) that this might be due either to the trade off between welfare (in a very broad sense) and the building of a new economy, or (more likely) to a positive relationship between a younger and more dynamic population and the building of a new Information Society.

Also related to human development and the welfare of the population, *Inequality* has a negative impact – though bigger than life expectancy at birth – in digital development. Thus, the greater the economic unbalances in the real economy the less likely this economy is to reach a higher stage of digital development. This is an interesting finding as it raises a cautionary remark that (digital) development goes hand in hand with a socially-balanced development strategy.

With an opposite sign, but with an impact as small as the case of life expectancy at birth, the *percent of urban population* also determines, in some degree, digital development. In this case, it does follow prior findings by other researchers that highlighted the importance to the development of the Information Society of clustering around cities as a focus of innovation.

Indeed, innovation and, more generally, the *economic incentive regime* plays a positive and more important role in the probability of reaching the stage of digital leader. We already mentioned when talking about the economic environment and R&D that the economic framework was a watermark of digital development. What we here find is that not only is it a watermark, but a cause in its full sense.

Moreover, the *Government prioritization of ICT* has the highest and most positive impact on digital development of all the determinants found in our model, multiplying by 18 the odds of an economy being allocated in the highest rank of digital development and three times stronger than the economic incentive regime. We have to be cautious, nevertheless, not to misunderstand prioritization with direct intervention, as the indicator measures the political and legal role of the government and not its direct participation in the economy.

Concerning less digitally developed economies, it is interesting to see that the causes of digital underdevelopment are similar (opposite) to those of development, with the inclusion of some particular aspects. So, we find that the determinants for not being digitally developed are Inequality (at 10%), Health Public Expenditure (% of total Health expenditure), Population covered by mobile telephony (%) and Importance of ICT to government vision of the future.

As we said, we find again *Inequality*, and again with a negative sign that has to be read carefully in this case. Regarding digital laggards, a negative coefficient in equality means that more inequality represents a lower probability of *not* being digitally developed, of being a digital laggard. In other words, higher inequality will decrease the probability of being a laggard. Though we can state that its power is lower than in the case of digital leaders, it is nevertheless surprising that more inequality would be "good" for digital development in its early stages. A possible explanation would be that of the last mile, where the deployment of infrastructures would never be completed if, at the margin, the cost of universal access overrides the

profits achieved by the carriers. Or, what is the same, a critical mass or a minimum threshold or purchasing power is needed in early stages of digital development.

Slightly lower in power, the role of the Government in the provision of health services (*Public expenditure in Health as % of total Health Expenditure*) has also a negative impact on the probability of being a digital laggard. In this case, the finding follows intuition: the healthier the population – and the higher the commitment of the government to their welfare – the better for development.

The *percent of the population covered by mobile telephony* is another confirmation of intuition, and in two different ways. First of all, it statistically demonstrates that mobile telephony is a driver of digital development in lesser developed countries, which is something that researchers in the field have stated to exhaustion – and by focussing, in their methodologies, on those technologies that are less affordable or have lower penetration, many ICT4D projects are implicitly denying this fact. Second, this is an indicator that does not appear when analyzing digital leaders but only in the case of digital laggards, which sort of pictures the structural differences between both groupings of economies and reinforces the need for separate policy designs to foster the Information Society when addressing such different realities.

If mobile telephony represents the difference between digital leaders and laggards, the *Importance of ICT to government vision of the future* surely represents the similarity. Though slightly different to *Government prioritization of ICT* among digital leaders, the over-riding concept is whether governments care about fostering the Information Society. And if the case of digital leaders was clear, it is even more powerful in the case of developing countries; orders of magnitude more important. On the other hand, while the case of digital leaders and the *Government prioritization of ICT* was the answer to the question of whether "ICTs is an overall priority for the government", the case of digital laggards and the Importance of ICT to government vision of the future wants to answer the question of whether "the government has a clear implementation plan for utilizing ICTs for improving the country's overall competitiveness" which is, to our understanding, a stronger commitment of the government, where not only its overall priorities are questioned but also whether real policies and strategies have been planned.

Our main **conclusion** in this section is that:

- Governments' actions determine digital development. The probability of a country of reaching higher stages of digital development is highly increased by governments prioritizing ICTs, by assigning a high importance to ICT in their vision of the future, and by establishing an appropriate Economic Incentive Regime.

At this point, we believe we have been able to answer the remaining research questions and, with that, to accept our hypothesis about the importance of the Government in enabling and fostering the Information Society by active political engagement– though not necessarily through direct intervention – with the facilitation of analogue and digital economies.

Our **general conclusion** is, thus, that:

- Narrow institutional interests and a lack of data lead to fragmented models to measure digital development that distort policy design. A comprehensive framework that includes all the relevant categories (Infrastructure – Availability and Affordability –, the ICT Sector – the Industry and the skilled Workforce –, Digital Literacy – the level of Digital Literacy and Digital Literacy Training –, the Policy and Regulatory Framework – Regulation and Policies – and Content and Services – Availability and Intensity of Usage –) would improve such models. Within that framework, the adoption of public policies to foster the Information Society would lead to higher stages of digital development.

Which confirms our general hypothesis of this research.

15.4. Limitations of this research

All that has been said up to this point in this chapter – and, actually, in this work in general – should be taken with caution (as one should with any kind of analysis) due to some limitations of the research, mainly related with the quality of data.

We have already stated several times along the preceding pages that data are far from being perfect. In general terms, their main shortages can be summarized as:

- Lack of data for a broad range of economies;
- Lack of data along time (i.e. time series);
- Use soft data, with lower quality than hard data;
- Use of proxies instead of hard (or even soft) data in variables to represent indicators, proxies whose relationship with the represented variables is not demonstrated (e.g. education vs. digital literacy);
- Like of consistency of some data (e.g. series of data for a set of economies on an indicator and for a specific year might actually gather data from several years, due to lack of data, surveys collected or sent back when formal periods are over, etc.);
- Lack of unified, coherent, comparable large data sets collecting large amounts of indicators under the same methodology.

In specific issues, main shortages can be summarized as:

- Generalized lack of data about digital skills, both level and acquisition;
- Generalized lack of data about usage;
- Generalized lack of microdata about specific usage (including the reasons for not being a user);
- Generalized lack of hard data on policies and regulation;
- Some existing data practically unavailable due to costs of fees (despite them being gathered by public or public funded institutions).

Absolutely all these problems are present in the data sets we used to perform our analyses. On the other hand, we feel able to say that having been able to work with our model despite these issues is, to us, one of our more successful outcomes.

Of course, we are not trivializing the consequences of working with such data: although we believe that our findings and conclusions are quite robust, new and better data would likely make them teeter, especially when close to the boundaries of statistical significance or in coefficients near to zero (i.e. they might change sign easily).

Concerning tests of significance, we were careful enough to prune out of models any non-significant variables and set aside whole models whose explanatory power was not significant either. Notwithstanding, we are fully aware that we have been working with small samples (statistically speaking), which became even smaller when we focused in individual clusters or stages of digital development.

As has already been stated, this was one of the main reasons why the leapfroggers' stage – composed of just three economies – was not analyzed in a logistic regression or why some initially appealing economies to our study – like Iceland – were not included in the working database.

The approach to deal with aggregate data at the country level is also a dire limitation of the model. The reader will agree that countries or nations are constructs that represent the regions comprised within their boundaries in many aspects, but that necessarily blur the heterogeneity of their inner differences and hide the differences – sometimes huge ones – amongst their regions or lower levels of aggregation. Though this limitation is closely related with lack of data, we thought it was worth mentioning it in a separate way, as it is also a matter of scientific approach and methodological design to include these sensibilities in our models.

Last, but not least, one could argue that not only data but the whole model itself could be better designed. We are fully aware that we have tried to maintain a neutral, practical approach strictly focusing on the tools, and neither on the frameworks nor in the goals. But a theoretical approach could – and should – be added to that approach of ours. Our subject of research is closely related with institutional design and its impact in society, economic development theory and human development theory, or public policies design and assessment, to name a

few. Matters of focus and length kept us aside from entering in deep with these disciplines. Nevertheless, we believe that some of these well established disciplines and their corresponding theories would have enriched our work.

On the other hand, we believe that not only is this a present problem, but a future one too: the ever-changing nature of technology puts at stake many theories and approximations within several months range (e.g. what is broadband, as defined by its lower capacity limit?). This would ask of models to be designed in dynamic terms and not statically. Following the example of broadband, to set aside quantitative considerations (e.g. raising the lower capacity limit to define broadband from 256 Kbit/s to 1 Mbit/s) and work in the field of "competences": e.g. "to be able to work comfortably online with any device and software". Of course, this adds a lot of subjectivity to the whole model, making us wonder whether the "solution" is worse than the problem. An approximation with structural equations with latent variables might be a better one. We deal with this proposal in next section.

15.5. Future lines of work

In our opinion, one of the most exciting and clear lines in which this research of ours should be expanded in the future is the refinement of the theoretical model or, so to speak, of the 360º digital framework. And, to do so in at least two ways.

A first way would be the strengthening of the theoretical corpus. In other words, one of the things that we have been doing in our research has been reviewing what had been done and put it all together. A (necessary) next step should be going one step beyond and building "new" theory from it by exploring all the relevant aspects of digital development still not covered in our work – and, maybe, not covered at all by people and institutions currently measuring and modelling digital development.

This enrichment of the theoretical corpus could also come from establishing relationships between our research and the field of e-Readiness and ICT4D and other disciplines like the afore-mentioned growth, human development, policies or institutional design. We nevertheless think that, given the topic of our research, there are two fields that naturally converge in our own field. The first one is what has been developed under the name of Knowledge Economy, which represents a "vertical" expansion of our work leading to explore the use of digital tools to the application of knowledge in all aspects of life – and, more precisely, in the production functions and growth. The second one is Network Theory – especially applied to policy-making – which represents a "horizontal" expansion of our work with the aim to gather all the collateral and synergic effects of networks, globalization, etc. in policy-making and the way Network Society works.

A second way would be to improve the fit and explanatory power of the applied model, especially in its predictive possibilities, further applications (micro and macro

levels, by sector, by smaller geographical units – e.g. nationally or regionally –, etc.) and flexibility according to data availability and specificities of the target to be measured. In this respect, the inclusion of time-series data rather than simply "latest available" would be an important methodological improvement, especially with regard to the ways in which individual countries transition between the stages of digital development. In general, *any* improvement in data – in the lines we mentioned in the previous section – would most likely improve the fit of the model.

These two goals or lines of work seem to converge in what looks a natural evolution of our work: the application of structural equation modelling. We believe that this technique would both provide a better approximation to the theoretical issue and also increase the explanatory power of the statistical part when put into practice.

It would, most likely, also increase the number of variables that the model can work with. Let us remember that, although our model used more than 60 variables when explaining the characteristics of digital development, nevertheless this variety – and comprehensiveness – drastically dropped to just five when performing the logistic regressions.

Better modelling, along with better data – as we already explained in the previous section – should enable the model to evolve into yet another line of work: specific usage at the "really-micro" level, the one which deals with usage in a qualitative way and focusing on the *purposes* for which technology, digital content and services are used, and not in the mere *use* of them (e.g. use of e-mail for obtaining health information).

Thus, the combination of a broad, macro, generic work such as ours with usage-focused ones could provide valuable insight into the constraints and multipliers of a digital framework, while being enriched by the practical focus of other applied researches (e.g. following the previous example, enablers and motivations of usage of ICTs for health-related issues).

And, lastly, a third line of work, which we consciously abandoned in our research, but that would make perfect sense in the light of these considerations mentioned above: to investigate the causes of leapfrogging. Due to the heterogeneity of leapfroggers, and the fact that only three of them have been identified, this is, by far, the most challenging line to explore. On the other hand, it is nevertheless and most probably the most interesting one, at least in its implications for policy development. As we have been seeing, a minimum stage of socioeconomic development does not guarantee digital development, but does certainly make things easier (i.e. it is a necessary condition, but not a sufficient one). The Philosopher's Stone would hence be to find out how poorer countries, starting off from a position of disadvantage, could make it to higher stages of development and welfare.

All in all, this is what the whole thing was about.

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