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The quantification of ICT development

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Abstract— **Nowadays, economy and society in the age of information base on results of production chain (information-knowledge-acquaintance), the motor of processes is handling structured knowledge and communication. Quantifying and measuring of differences of the information society's different parts raise similar problems like the question of the concept's definition itself. Our main problem is defining information society in any other way, then we also have to measure in a different way maybe with different variables and methods. It follows that the topic contains wide range of measurable variables: several explaining variables can be listed from infrastructural parts measured in the most easiest way through knowledge-part can be measured a bit harder till hardly tangible willingness for using information. That is why most of the studies work with groups of variables and complex indexes as there is no one-dimension indicator can be measured simply and could be considered as an own one by any of the information societies. The measurement of factors generally raises different problems that can only be solved in different ways, therefore unified schemes or scenarios cannot be used for measuring a new factor. It is also important to note that it is not necessary to include all factors in everyday statistical surveys.**

Keywords*— *Digital Access Index, Information Society Index, Digital Opportunity Index, INEXSK, i2010,

I. INTRODUCTION

In the beginning of the 20th century, the measure of economical and social changes was defined by quantity-indicators of produced materials, in which quantity of tons of coal or steel production was prevailed. Around in the middle of the turn of the century energy consumption, produced kwh of electricity, quantity of used fuels and numbers of kilometres are done by aviation and train service became significant. Nowadays, economy and society in the age of information base on results of production chain (information-knowledge-acquaintance), the motor of processes is handling structured knowledge and communication [1].

Quantifying and measuring of differences of the information society's different parts raise similar problems like the question of the concept's definition itself. Our main problem is defining information society in any other way, then we also have to measure in a different way maybe with different variables and methods. It follows that the topic contains wide range of measurable variables: several explaining variables can be listed from infrastructural parts measured in the most easiest way through knowledge-part can be measured a bit harder till hardly tangible willingness for using information. That is why most of the studies work with groups of variables and complex indexes as there is no one-dimension indicator can be measured simply and could be considered as an own one by any of the information societies.

At the same time we cannot consider the measurement of the information society's part as a complex, multi-variables measure development task. The quantification of some of local social components raises measurement issues. Factors should be measured regarding information society and economy can be divided into two parts: we have to examine measurement opportunity of certain parts and we also have to discover the differences of information technology's development we can get with the help of forming complex variables and using similar complex examination techniques.

Measurement probes are partly helped by using principally and previously-used indicators regarding the economy and the information society as well. But with the appearance of new symptoms in the information society, variables or rather measure factors appeared that had never been used before. Some of them can be easily quantified followed by former measure techniques and samples, but others – these mean the real challenge – do not show any commonality with former variables by their nature, so need new kind of measure techniques. Not only the newly appeared phenomena in the economy and the information society can be defined as new issues and challenges but also to define and measure certain special parts within. In case of new and transforming local inequality factors measurement questions are raised by the fact that most of the informant system is able to follow changing of factors only with some delay. This kind of following cannot be considered in every case as a disadvantage. For choosing the appropriate unit and technique needs time: needs time to get known the dissimilar touch of the existing new or transforming factor and to form our new technique deferring to it. In that case if this monitoring period would be too short (we would have almost present, continuously adaptable and varying data publication) we

could give a hardly comparable timeline based on our continuously measured data. As technique of measuring changing factors has already been settled and only small changes need to be done, in case of new factors we cannot rely on bases like these. In some cases measure problems were not experienced before might be arisen due to the variegation of newly appeared factors and new techniques need to be provided (see also measurement of content providing).

In some other cases, though the factor is new to measure, it can be equal to measure factors existing for a long time. Beside this, field researchers need factors to be disassembled into parts, namely for measuring area units. We can realize in case of several factors that surveys do not take this demand into consideration, although there is available information about broader nationwide trends. In case of new factor's measurement the main problem is picking apart areas is too difficult even though the factor itself can be measured easily.

Among the new indicators of the 1990's, the indicator of PC-supply is a good example of the case mentioned above. Most of data are not published in area classification or if they are, it happens at a level of extensive aggregation or maybe in an estimated form. In case of this indicator the result of measure technique is difficult area explanation, precisely less reliable area results can be conducted from survey, because of the nature of the technique. Measurement of PC-supply mostly happens in household-statistics survey, which is more irresponsible than a survey of sphere has duty of registration like corporations (market) or state. We have to separate the survey of hardly measured home PCs and PCs for education, trade, government might be measured easier in the indicator of PC-supply. In the case of the aforementioned household-statistics survey techniques and representative ones, in the case of the latter one file-register forms (inventory, accounting) can be used.

There are further factors as well, where household-statistics can be used. Measurement of mobile-phone availability follows by the technique of phone, fax, radio or TV substance, but to pick apart local is not really clear. Area level measurement of number of mobile phone subscriptions is absolutely unsolved against measurement of owning television. Hungarian mobile service providers handle the number of subscribers as a trade secret and sometimes publicize only estimated or nationwide data. If mobile subscriptions become public (like a directory), area identification of subscribers is going to be possible, so to compile territorial data. We have to pay our attention to the fact that one subscriber can have more phones or more people have one (partner card system) and mostly the real user of the phone is not the subscriber (company phones).

If we can solve these problems, we still have the difficulty of how to define area mobile communication.

Infrastructural factors seem to be more measured ones as society factors. Measurement of number of computers in network means less problem as measurement of them in net-communication, but it is still not simply to count these PCs. The easiest way of counting the PCs having network connection - as in lot of other cases, in this as well – can be done by compiling a list at institutions (enterprises). Area information can be defined as an information in the headquarters of the institute or enterprise (a more detailed information is possibly insolvable). Network connection of home computers can be got to know by a household survey. To count the number of users is easier. The indicator of numbers of internet subscribers can be defined or registered locally easier. We can get the residential and institutional data from database of internet provider companies.

Following international tendencies, we can find several factors within new ones, which do not act on foregoing measurement exercise. Most of the new factors arising by the increasingly expanding information society need new monitoring techniques in several elements. Content-service used as an indirect indicator of informational activity and the quantity indicator of e-commerce can be counted difficulty. Measurement techniques of these kinds of activities have not been worked out yet, so far I have only information from indirect sources and I have estimated data about their measure. Until the concepts themselves like e-commerce, network content, information service is not clearly defined (professionally), their reliable measurement cannot be solved either. Initial viable might be the direct measurement of this factors or representative survey or cooperate data collection which do not offend business secrets.

Sometime in the turn of the millennium within new factors were arisen with information society we can find ones that can have a financial-statistical approach. A long-standing technique is the autonomous evaluation of budget heading, supposing that these are in appropriate dissociation, appropriate contents in the examined budget. In case of incomes and also expenses, new factors can be found, which provide direct or indirect picture of the new ones. By this technique we can get information about hardware and software costs, network costs or incomes of launching ICT products. The functional implementation of it in the public administration and business sphere can be found out from yearly budgets

The practical realization of the survey can be identified from the data of annual budgets in the administrative and business sphere, in the case of the populace it can be deducted by using surveys on expenditure (or consumption) structure. Since the majority of these population-related surveys are representative, that is, not based on the responses of the whole population, the classification of territorial units and the evaluation of survey results should be analysed with certain caution.

It is important to note that the clarification of the measurability of a transforming or newly-appeared factor together with finding answers to the arising methodological questions can only be performed in a separated way.

The measurement of factors generally raises different problems that can only be solved in different ways, therefore unified schemes or scenarios cannot be used for measuring a new factor. It is also important to note that it is not necessary to include all factors in everyday statistical surveys.

II. HOUSEHOLDS AND THE NATION

The primary sources of the official statistics presenting on the development of the information society in the EU are those regularly repeated surveys (sometimes including tens of thousands of respondents that are extended into all member states and, in numerous cases, into the countries waiting for accession). The subject of these surveys is the demand side of the market for info communication products and services. Their population consists of households, individuals and business organizations; their methodology is occasionally harmonized by Eurostat. In the case of household surveys, one way of harmonization is to publish recommendations on sampling strategies, the content of questionnaires and the definitions of terms and indices included in questionnaires.

Large-sample surveys are complemented by projects in which questionnaires are sent to the governments of the member states in order to get a full review on the expansion of information and communication technologies in institutions such as central government organizations, local governments, education and health institutions. These surveys are carried out by independent consulting agencies. The review of the development of e-government services in the member states of the EU is based on such surveys.

In Hungary, data on households and the information society are mainly provided by casual surveys that are conducted by several independent organizations serving business, government or scientific needs. The orders for such projects generally come from government institutions or telecommunication companies, while the actual surveys are conducted by universities, consulting, market and polling companies [2].

Surveys on the population's demand for and attitudes towards information technologies are generally based on a limited number (1000 to 3000) of responding households or individuals.

The topics of the questionnaires included in such surveys are as follows:

1. ICT-availability in households,
2. habits of computer use,
3. habits of Internet use,
4. measurement of the penetration of e-commerce,
5. knowledge needed for using computers and the Internet,
6. yearly household expenses on ICT.

The questionnaires are based on Eurostat's recommendations. The results are published in the following autumn. The results are also used for composing individual indices. With the help of these indices each country is ranked and evaluated.

Numerous surveys are conducted on e-readiness and competitiveness across the globe year after year, comparing as many as 60-180 countries. The strength of e-readiness rankings is given by the fact that its makers are able to evaluate the development of the surveyed countries by using few, well-chosen indices. In most cases, these rankings are made up of complex indices that are composed of subindices. Despite this multidimensional analysis, these rankings are not aimed at giving a detailed analysis of the individual countries.

Mostly predetermined - quantitative and measurable - indices give the basis for the rankings. A part of the analyses almost exclusively puts an emphasis on economic indices by reviewing the development level of infrastructure in the fields relevant for the information economy. In the case of other lists, much more attention is payed to social indices, which means that the social effects of economic and technological changes are also part of the international comparisons and evaluations between countries.

The methods and the international rankings designed for measuring the e-readiness level of a country have lost their popularity recently but they have not disappeared for good. The results of the traditional and longitudinal researcher were available even in 2007 (for instance, IDC-World Times: Information Society Index (IDC); International Telecommunication Union: Digital Access Index and Digital Opportunity Index (ITU); Economist Intelligence Unit (EIU)).

If someone would like to get a more general picture about the e-readiness levels of the countries around the world, it is enough to take a closer look at these three well-known and comprehensive indices mentioned above. However, case studies may be needed to get a more detailed picture.

A. Information Society Index (ISI)

From the middle of the 1990's when ISI appeared, a lot of changes were taken place. Followed by these changes (especially the technological ones), the original methodology was modified in 2003, so since then several new factors, such as the rate of households having broadband internet access, users of mobile internet, development of softwares and the number of wireless phone subscribers have been calculated in the rank. For calculating the index, computers, telecommunication, WEB and development of social factors are considered.

About the index we can tell that the place in the information society ranks mostly correlate with the society and not with computer or internet factors: the higher the score from social factors the more possible for a country to be in a favourable place in the rank.

B. Digital Access Index

The oldest operating professional union of the world, the International Telecommunication Union was founded in 1865, Paris. This union scores the Digital Access Index, DAI. The first issue of Digital Access was made for the conference of World Summit on the Information Society (WSIS) in 2003. The list contained 178 countries, but in 2005 there were only 40 countries to be ranked. The index was made for being effective help of comparative international examination for ICT access and use. One of the important aims of DAI is helping to eliminate the digital divide. This is the first index based on internationally accepted ICT indicators.

Makers of DAI, in case of its measurement considered not only infrastructural factors but e.g. the level of education or the issue of affordability and these factors were aggregated in between 0 and 1 in order to make a rank.

Four quality categories were made:

- excellent,

- top,
- middle,
- low.

In the course of analysis five components are examined (infrastructure, business environment, consumption and economical adaptation of e-trade, society and cultural environment, legal regulation) and certain aspects are weighted differently at making the final rank.

C. Digital Opportunity Index

Digital Opportunity Index (DOI) was introduced at the World Summit on the Information Society (WSIS) closed in 2005. An action plan accepted in an earlier part of the meeting expressed the need of a comparative methodology that can help to evaluate the performance of certain countries. Consistent examination of the declared aims, the use of compiled indicator-system gives opportunity to make comparisons beside evaluation. The index contains 11 indicators; as a consequence it can be ranked among less complex indices. Components can be ordered into 3 bigger classes, they examine the use and opportunities beside infrastructure. Comparing the complex indicators and examining the use of opportunities of ICT applications, it turns out that DOI is one of the most complex surveys, at present data of 180 countries are available.

D. Economist Intelligence Unit

EIU is the biggest not investment bank like economic forecasting institute of the world. EIU and Pyramid Research analysed the situation and the readiness of 60 countries together at the first time in 2000 for the information age. Countries are compared in 6 categories since the methodological modification in 2001 (connection, economical environment, e-commerce, legal regulation, support of e-services) based on 100 different indicators.

EIU divided the countries into four groups:

- use ICT daily,
- ICT is developed (quick adaptation of e-services),
- ICT is developing,
- ICT is not developed.

E. ORBICOM/ITU ICT possibility index

ICT possibility index (ICT-OI) alloys economical aspect, rate of labour in the field of ICT- production and social approach, mainly use and share of information and further human factors are involved. Dimension of information density as defined by base network and human factors, while use of information focuses on ICT infrastructure and human factors [3]. A Canadian civil organization helped in working out the methodology is called ORBICOM and ITU. Among indices focusing on ICT this one is the most appropriate for drafting long run trends. The ICT Possibility Index basically came from digitally division's discourses; results of certain countries are compared with the average of 180 countries, the imagined state of Hypothetical, taking part in the survey. Four big groups were created in it, having the most developed, developed, medium and low value of ICT-OI index.

F. The use of indices

It is important to emphasize that comparing lists can be done very carefully, mainly in case of declaring winners-losers: because of different methods, the primary use of different time frames, different factors and importance the same country can be a winner on one list and loser on the other. It does not really mean error because list of certain parts of ISI shows different ranks, so even among one rank can be differences in the field of certain country's judgement – but it is a proof that the way of measurement is more determinative than the performance of countries.

The determining critics regarding prepare examinations is an insensibility for alternative development. This mainly comes from universal, global methodology, in every county the same technology platforms are examined, though the information society can be based on different infrastructural bases in certain countries. For these factors – can be traced back to cultural ones – the big international comparative examinations are less sensible.

G. INEXSK examination technique

The name of the international wide technique is an acronym (Infrastructure, Experience, Skills, Knowledge), which refers to the complexity of this technique. It is used for examining the common effect of infrastructure experience, skills and knowledge in the comparative studies on the information society. The process does not yield a one dimensional index, as formerly known or a kind of index but a structural picture can be done in every square-unit in the same order. The aim of the technique is to point to the way that level of infrastructure, experience and skills contribute to knowledge based economical growth and development. The technique aims to give answer the question by specially representing graphic factors can be considered, so the given diagrams are going to be the outgoing results of INEXSK-technique. The following diagram shows that the technique summarizes the examined factors in a logical system based on each other. The base is the level of infrastructural availability, a factor that shows how wide or narrow a base can be for the development of skills and experiences. Production and consumption experiences - which are showed up in an indicator brought in the next step –, represent the phase of increase of accumulated knowledge (experts concordantly say that significant part of attained knowledge is built up during production and consumption). In the third step, indicators of production and consumption skills come up, which are accompanied with firm empirical parts. The last step on the upper part of the diagram is called ideal knowledge indicator is emblematical only and sign the use of knowledge and its development of intensifying on behalf of social and economical development.

Indicators on the bottom part of the diagram enhance and generally make possible efficient use of factors are on the upper part of the diagram. Its interaction shows that attained production and consumption experiences by new technological application effect on the direction of increasing the attained knowledge (see arrows on the upper part of diagram).

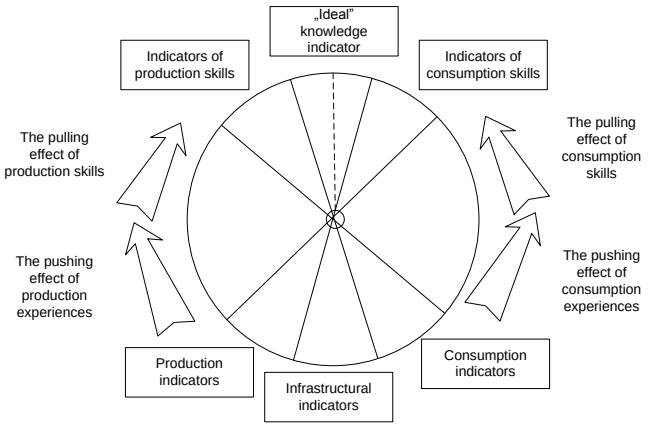

Fig. 1 The dynamic scheme of the structure INEXSK

Neither production nor consumption alone, however, will bring infrastructure assets and experience into productive use in the creation of knowledge. This requires `pull' influences from the production or consumption skills, represented by a second set of arrows leading to the skills level. Finally, the diagram has a relatively larger gap between experience and skills indicators than between infrastructure and experience, or skills and knowledge. This gap reflects the difficulty in coordinating the `push' of experience and the `pull' of skills to achieve an effective outcome.

For infrastructure, the traditional measure is the size and growth of the telecommunication network. Telephone networks provide a broad base for building other types of infrastructure, such as data communication networks, but cannot serve as the only indicator of development. Unfortunately, few other indicators are as comprehensive as those associated with telecommunications. Where more detailed information is available, telecommunication indicators can be shown to be reasonably good proxies for other variables. (For example, where it can be examined, the extent of data networking appears to be consistent with high levels of telephone access.)

To understand the contribution of experience, electronics industry production and demand can be examined. These are indicators of the ICT production capacities of various countries, and of the domestic use and export or import of electronics products. Although production and use of electronics products are only partial measures of the ICT revolution, they do provide insight into the vigour of the social and economic changes that are associated with the process of moving toward greater knowledge use in societies throughout the world. In examining skills, it is vital to develop measures that indicate the state of readiness to enlarge the use of information to develop knowledge. A principal indicator of such readiness is the literacy level. It is also important to develop measures of the skills that may be harnessed in producing or adapting ICTs. The stock of graduates with technical degrees in engineering, mathematics, and computer science is relevant here. The chart introduced by Mansell and Wehn brings together indicators from each of the categories, that is, infrastructure, experience, and skills, in a charting technique called the `ICT footprint'. The `footprint' technique is developed from the INEXSK framework [5]. It can be used to make inter-country comparisons and to benchmark the performance of different regions in preparing for, and participating in, the ICT revolution. It is also a means of organising the thinking about how other measures might be derived and used in the construction of international comparisons and strategic planning studies.

TABLE I
INDICATORS APPLIED TO COMPREHENSIVE ICT STRUCTURE SURVEYS

Indicator	Computation used	Country taken as 100
Personal computer index	Personal computers per capita	New Zealand
Main lines index	Main telephone lines per capita	Sweden
Electronics production index	Share of electronics revenue in GDP	Ireland
Electronics consumption index	Per capita 'consumption' of electronics as a share of GDP per capita	Ireland
Technical Graduates Index	Total graduates per 1,000 population	The Netherlands
Literacy Share	Percentage of population that is literate	None (100% taken as 100)
Internet hosts Index	Internet hosts per 1,000 population	Denmark
Television Set Index	Number of television sets per 100 population	The United Kingdom

Eight indicators are chosen based on data availability and their value in provoking thought about different patterns of development in knowledge societies. Three factors were important in constructing the indices. First, it is desirable to adjust for population in measures of infrastructure and skills. A larger sized country will often have a larger infrastructure or a larger number of skilled individuals, but not necessarily higher levels per inhabitant. All the measures of infrastructure and skills as well as the two measures of `outcome', Internet hosts and television sets, are adjusted for population. Second, in developing an indicator for production and consumption experience it is desirable to measure the relative specialisation of the economy in electronics. For these measures, the share of electronics in GDP is used to `scale' the size of electronics experience in the total economy. Third, it is desirable to graph different countries on a common scale. Therefore, one country must be chosen as the `extreme' or highest level against which to benchmark the level of other countries. Several of the values for the indicators are very high for a few countries, and it is not desirable to choose the country that is absolutely the largest in the world. This would mean that a great many countries would have very small values on the index. An approach was used to select the country `taken to be 100' in the analysis. The available indicators are particularly deficient for developing and smaller countries. These limitations prevent the comparison of many countries for which useful

insights might be developed using this technique. For those desiring to replicate the technique, different indicators might be chosen based upon the availability of data.

III. ENTERPRISES AND ECONOMIC SECTORS

A Communication on the Commission's new i2010 strategy was adopted on June 1. i2010– European Information Society 2010 aims to exploit opportunities for economic growth and jobs in Europe by promoting an open and competitive digital economy. It is a key element of the renewed Lisbon Strategy and offers a comprehensive strategy for the ICT and media sector [7]. It proposes three priorities for Europe's information society policies:

i) the completion of a Single European Information Space which promotes an open, competitive and content-rich internal market for electronic communications, media and content;

ii) strengthening Innovation and Investment in ICT research to promote growth and jobs through a wider adoption of ICT;

iii) achieving an Inclusive European Information Society that prioritises better public services and quality of life.

Benchmarking plays a central role in monitoring progress in achieving these i2010 priorities. In each case, a mix of indicators is needed to measure the different aspects of the objectives that are to be achieved. Policy emphasis now focuses more on complex issues of impact and usage of technologies in the wider economy and benchmarking must become more sophisticated. It is necessary to build on existing work and continue to track some indicators consistently but monitoring of progress now requires indicators that are flexible and timely [4].

The Commission will monitor progress through an annual European Information Society Progress Report. The report assesses developments and impact and indicates where additional measures may be needed.

i2010 is fully in line with the new Lisbon governance cycle defined in the revised Lisbon strategy and based on the following [6]:

- Adoption of integrated guidelines for growth and jobs for the period 2005-2008 on the basis of the Commission proposal ,
- Adoption of National Reform Programmes by Member States based on these guidelines.
- Adoption by the Commission of a Community Action Plan covering all actions to be undertaken at European level in support of the goals of growth and employment .
- Reporting in spring on progress achieved both at the national and EU levels.

Given the tight link between i2010 and the Lisbon process, it is important to establish a correspondence between benchmarking and i2010 indicators and the integrated guidelines relevant to ICT:

- Guideline 7. Increase and improve investments in research and development, in particular in the private sector, with a view to establishing a European area of knowledge.
- Guideline 8. Facilitate all forms of innovation, Member States should facilitate the uptake of ICT and related changes in the organisation of work in the economy.
- Guideline 9 : Facilitate the spread and effective use of ICT and build a fully inclusive information society
- Guideline 16: Expand, improve and connect European infrastructures and complete priority cross-border projects
- Guideline 21: Promote flexibility combined with employment security and reduce labour market segmentation through: geographic mobility; the promotion and dissemination of innovative and adaptable forms of work organisation.
- Guideline 24: Adapt education and training systems in response to new skill requirements through: better identification of occupational needs and key competences, and anticipation of future skill requirements.

The i2010 benchmarking definitions therefore makes an important contribution to the Lisbon process and feeds the discussion of the structural indicators.

IV. CONCLUSIONS

The primary sources of the official statistics presenting on the development of the information society in the EU are those regularly repeated surveys (sometimes including tens of thousands of respondents that are extended into all member states and, in numerous cases, into the countries waiting for accession). The subject of these surveys is the demand side of the market for info communication products and services. Their population consists of households, individuals and business organizations; their methodology is occasionally harmonized by Eurostat. In the case of household surveys, one way of harmonization is to publish recommendations on sampling strategies, the content of questionnaires and the definitions of terms and indices included in questionnaires.

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Numerous surveys are conducted on e-readiness and competitiveness across the globe year after year. The strength of e-readiness rankings is given by the fact that its makers are able to evaluate the development of the surveyed countries by using few, well-chosen indices. In most cases, these rankings are made up of complex indices that are composed of subindices. Despite this multidimensional analysis, these rankings are not aimed at giving a detailed analysis of the individual countries.

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