Romania's Development towards the Knowledge Economy: the ICT Dimension

Zizi GOSCHIN, Daniela-Luminiţa CONSTANTIN
Academy of Economic Studies, Bucharest

This paper attempts to contribute to the existing research by providing new data and information about Romania's advance towards the knowledge economy. In particular, two research questions will be envisaged. First, the role of information and communications technologies in economic development will be discussed in connection with its relevance for assessing the progress in knowledge economy. Second, Romania's position both in ITC and knowledge economy will be examined in a European and international context. With this aim in view a series of literature insights will be combined with a methodological framework and relevant statistical data analysis.
Keywords: *Knowledge Economy Index, ICT Index, Romania's basic scorecard.*

Introduction. At present it is unanimously acknowledged that the new stage of the market-based economy is more strongly and more directly rooted in the production, distribution and use of knowledge. Knowledge creation and knowledge diffusion are key driving forces in the economy and knowledge has become an economic resource in its own right (Fischer and Atalik, 2002). Accordingly, firms are more and more interested in absorbing the advances in technological and organizational knowledge and in applying it in the production process and organization of work.

In this context, any discussion about knowledge invariably leads to the question of the relationship between information and knowledge. Thus, according to Fischer, the common understanding is that "information does not become knowledge unless its value is enhanced through interpretation, organization, filtration, selection or engineering" (Fischer, 2002, p. 18). Moreover, nowadays the ICT revolution and the knowledge-based economy are closely interrelated. The convergence of computing, information and telecommunication technologies has changed the conditions for the production and dissemination of knowledge and its connection with the production system as well. New flexible information and communication technologies such as internet, web, intranet, extranet, data warehousing and data mining, as well as collaborative groupware technologies are responsible for the major changes in current abilities to handle data and information, to codify knowledge and to transmit codified knowledge (Fischer, 2006).

Starting from these overall considerations this paper attempts to contribute to the existing research by providing new data and information about Romania's advance towards the knowledge economy. In particular, two research questions will be envisaged. First, the role of information and communications technologies in economic development will be discussed in connection with its relevance for assessing the progress in knowledge economy. Second, Romania's position both in ITC and knowledge economy will be examined in a European and international context. With this aim in view a series of literature insights will be combined with a methodological framework and relevant statistical data analysis.

The ICT "revolution". There are many different definitions of information and communications technologies in the economic literature and business. They have been accompanied by numerous discussions about the relations between information technology, information and communication technology, information systems, and electronic commerce technology as well. The World Bank Group defines information and communications technologies (ICT) to consist of hardware, software, networks, and media for

collection, storage, processing transmission, and presentation of information in the form of voice, data, text, and images. They range from the telephone, radio and television to the Internet (World Bank, 2003a and 2003b).
With relatively low usage costs and the ability to overcome distance, ICTs have revolutionized the transfer of information, knowledge and technology around the world.
There has been a series of recent studies showing that both ICT production and ICT usage have contributed to economic growth (Chen and Dahlman (2004), Pilat and Lee (2001), Jorgenson and Stiroh (2000), Oliner and Sichel (2000), Whelan (2000).)
ICT infrastructure in an economy refers to the accessibility, reliability and efficiency of computers, phones, television and radio sets, and the various networks that link them. Any improvement or rise in the level of the economy's ICT infrastructure increases the efficiency in the utilization of the existing technology and enhances the production of innovation and discoveries. ICT usage also increases the rate of human capital accumulation because it enlarges the access to existing knowledge and information (World Bank, 2003b).
The fast grows in capital spending on information technology and its impact on many different aspects of economy has been discussed with the help of the conceptual models (Davenport and Prusack, 1997). However, only recently empirical studies about the relation between information technology and economic performance have been performed. A review study of these empirically grounded models was presented by Dedrick, Gurbaxani, and Kraemer (2003), who found that information technology has a positive and significant impact on labour productivity and economic growth. Fuglseth and Gronhaug (1994) pointed that humans are the basic element in every information system and if employees do not use new information technology in their work processes then the investments should not be made.
Information technology in various forms and combinations ranging from the Internet, WWW, HTML and XML to different applications and systems including enterprise resource planning, customer relationships management and enterprise application integration, are enabling and facilitating economic processes and creating new business contexts for companies to operate (see e.g. Angeles, 2000, Porter, 2001). The Internet, the web browser, and other information technology have made digital interactions possible between individuals and corporations. The seller and the buyer do not have to meet in person but they can interact digitally through their supply chain. We now face a new phenomenon in the use of information technology as many of the products, services and information can be digitized (converted to bits) and delivered to customers via or with the help of the Internet (Shapiro and Varian, 1999).
The producers of goods have accelerated this evolution since the information has gained a bigger place in almost every offer. In the same register, according to a largely diffused interpretation, internet would allow a better circulation of information regarding tenders or the creation of electronically specialized markets. This would determine a more intense competition between firms and important changes in the profit margins of the producers of components and commodities. According to Cappellin (2002), this should imply a decrease of costs that may vary from sector to sector but could range from 5% to 15% in telecommunications and up to 30% in the case of electronic components.
The movement towards open standards (RosettaNet, Linux, the Internet and Web development) has provided efficiency and flexibility gains to organizations involved and employing them. For example the Internet-based information technology infrastructure is meant for sharing information through the telecommunication network and it has many users. It was developed originally for text and some pictures but now it is frequently used for the video streaming and consequently the second generation of the Internet was developed. Furthermore, the information technology infrastructure for the Internet, the Extranet, and the Intranet is created and used

through open source codes and common standards. Since the cost of adding connection is very low and it is more feasible nowadays, the number of connections has rapidly increased. The Internet also offers lower implementation cost and fosters standardization of data formats and coordination of those flows by making data sharing economically viable to more firms. Therefore, managers standardize data with other supply chain members or become compliant with the industry standard like RosettaNet (Hannula and Vasama, 2002). All this means that companies must make conscious decisions related to interoperability between software, hardware, databases and infrastructures. These all are important elements of information technology strategy.

A methodology for international comparisons in the knowledge economy. Information and communications technologies represent an effective tool for promoting economic growth and sustainable development and in recent years have also been recognized as the backbone of the knowledge economy (World Bank, 2004). One of the most obvious benefits associated with ICT usage is the increased flow of information and knowledge. Because ICTs allow information to be transmitted relatively inexpensively and efficiently, ICT usage enlarges the flow of information, technology and knowledge, and hence technologies can be acquired and adapted more easily leading to increased innovation and productivity. Intuitively, the enhanced flow of information and knowledge, resulting from the improvement in the ICT infrastructure, allows innovation to be produced more efficiently, holding constant the level of existing technology.

The ICT is considered to be one of the four pillars of the knowledge economy (Chen and Dahlman, 2005):

1. ***Economic Incentive Regime*** is referring to the economic and institutional conditions that provide incentives for the efficient use of existing and new knowledge and the flourishing of entrepreneurship.
2. ***Education***: an educated and skilled population can create, share, and use knowledge well.
3. ***Innovation***: an efficient innovation system of firms, research centers, universities, consultants and other organizations can tap into the growing stock of global knowledge, assimilate and adapt it to local needs, and create new technology.
4. ***Information Communications & Technology*** is important because a dynamic information infrastructure can facilitate the effective communication, dissemination, and processing of information.

The World Bank Institute has developed a Knowledge Assessment Methodology- KAM which benchmarks the knowledge economy performance of an economy or region relative to its neighbors, competitors, or countries. This tool helps to highlight countries progresses and to guide the development of explicit strategies to harness knowledge to improve growth, welfare and increase competitiveness. It wishes to emulate on important aspects related to the knowledge economy.

ICT is an important part of the **Knowledge Economy Index (KEI)** –a composite index which is a measurement of knowledge preparedness of a country and allows for benchmarking and comparison of regions and/or countries based on their aggregate performance. It can facilitate comparison of any particular country or region with other regions and/or any countries of the total 121 countries currently covered in the database. The Knowledge Economy Index is derived by the Knowledge Assessment Methodology (World Bank, 2004), based on the average of the performance scores of a country or region in 76 variables relevant for a country preparedness for the knowledge economy.

The set of 76 variables serve as proxies for the conditions that are critical to the development of a knowledge economy and is structured in 7 groups: performance indicators (6 variables), economic regime (7), governance (6), education and human resources (15), innovation system (19), information infrastructure (12), gender equality (5). The ***Information Infrastructure variables*** are the

following:
58. Telephones per 1,000 people, 2002 (telephone mainlines + mobile phones) International Telecommunication Union, 2002)
59. Main Telephone lines per 1,000 people, 2002 (International Telecommunication Union, 2002)
60. Mobile phones per 1,000 people, 2002 (International Telecommunication Union, 2002)
61. Computers per 1,000 persons 2002 (International Telecommunication Union, 2002)
62. TV Sets per 1,000 people, 2001 (World Development Indicators, 2003)
63. Radios per 1,000 people, 2001 (World Development Indicators, 2003)
64. Daily newspapers per 1,000 people, 2000 (World Development Indicators, 2003)
65. Investment in telecom as % of GDP 2000 (IMD World Competitiveness Yearbook, 2003)
66. Internet hosts per 10,000 people 2002 (International Telecommunication Union, 2002)
67. Internet users per 10,000 people 2002 (International Telecommunication Union, 2002)
68. International telecommunications: cost of call to US in $ per 3 minutes, 2001
(World Development Indicators, 2003)
69. E-government (WEF Global Competitiveness Report, 2002/03)
70. ICT Expenditures as a % of GDP 2001 (Statistics Information Management System, World Bank Internal database system).

As working with a large set of 76 variables can be difficult, a simplified "basic scorecard" of 12 variables has been developed : average annual GDP growth (%), Human Development Index, tariff and non-tariff barriers, regulatory quality, rule of law, adult literacy rate (% age 15 and above), secondary enrolment, tertiary enrolment, researchers in R&D, per million population, patent applications granted by the USPTO, per million population, scientific and technical journal articles, per million population, telephones per 1,000 persons, (telephone mainlines + mobile phones), computers per 1,000 persons, Internet users per 10,000 persons.

The data are collected from World Bank datasets and international literature for 76 variables and 121 countries. Ranks are allocated to countries based on the absolute values (raw data) that describe each one of the 76 variables (rank u). The rank equals 1 for a country that performs the best (it has the highest score) among the 121 countries in the sample for a particular variable. The rank equals to 2 for a country that performs second best, and so on. Countries with the same performance are allocated the same rank. For each country, the number of countries with worse rank (Nw) is calculated. The following formula is used in order to normalize the scores for every country on every variable according to their ranking and in relation to the total number of countries in the sample (Nc) with available data:

Normalized (u) = 10*(Nw/Nc)

The above formula allocates a normalized score from 0-10 for each of the 121 countries with available data on the 76 variables, 10 being the top score and 0 the worst. The top 10% of performers gets a normalized score between 9 and 10, the second best 10% gets allocated normalized scores between 8 and 9 and so on. As mentioned before, more than one country may be allocated either the top or worst of normalized scores. The 0-10 scale describes the performance of each country on each variable, relatively to the performance of the rest of the country sample. The results are presented in the next section.

The case of Romania in international context. Applying the methodology previously described, the normalized scores for the four pillars of the Knowledge Economy Index (KEI) were selected for a number of 20 countries, Romania included. The results are displayed in Table 1 and Figure 1. One can easily notice that Romania holds a backward position not only in comparison with the US and Japan but also compared to the EU countries and, to a great extent, to Russian Federation (Romania has a higher score than the Russian Federation only for economic incentive regime).

Table 1. The Knowledge Economy Index (KEI) and the four pillars of the knowledge economy by country in 1995 and 2005*

Country	KEI		Economic Incentive Regime		Innovation		Education		ICT	
	recent	1995	recent	1995	recent	1995	recent	1995	recent	1995
Denmark	9.23	9.08	8.82	8.54	9.42	9.25	9.20	9.01	9.48	9.53
Finland	9.12	9.21	8.79	8.46	9.71	9.56	9.16	9.15	8.84	9.66
United States	8.74	9.13	8.26	8.36	9.42	9.60	8.38	8.81	8.91	9.74
Netherlands	8.73	8.87	8.51	8.56	8.63	8.67	8.67	9.12	9.08	9.14
United Kingdom	8.67	8.84	8.36	8.56	8.62	8.74	8.44	9.12	9.25	8.94
Switzerland	8.65	8.88	8.61	8.51	9.41	9.44	7.42	8.04	9.16	9.51
Germany	8.48	8.63	8.19	8.36	8.80	8.82	8.07	8.67	8.85	8.68
Japan	8.42	8.63	7.88	8.15	9.27	9.38	8.15	8.46	8.36	8.55
Belgium	8.28	8.51	7.98	7.98	8.52	8.50	8.65	9.30	7.97	8.28
France	8.21	8.52	7.81	7.83	8.46	8.66	8.44	8.96	8.13	8.62
Spain	7.93	7.93	7.88	8.45	7.75	7.34	8.41	8.40	7.69	7.55
Italy	7.66	7.61	7.07	7.25	7.14	7.53	7.84	7.77	8.58	7.88
Czech Republic	7.57	7.41	7.35	8.33	7.34	6.62	7.55	7.20	8.04	7.49
Hungary	7.28	6.78	7.40	5.84	7.10	6.84	7.60	7.35	7.04	7.07
Greece	7.11	7.29	7.15	7.27	6.95	6.78	7.52	7.54	6.82	7.57
Slovak Republic	7.10	6.80	7.15	6.79	6.84	6.66	6.85	6.81	7.56	6.95
Poland	7.04	6.48	6.82	4.92	6.44	6.49	8.08	7.99	6.80	6.51
Bulgaria	6.13	6.31	4.79	5.17	6.12	6.75	7.41	7.01	6.21	6.29
Russian Federation	5.98	5.85	2.70	1.84	7.52	7.87	7.71	7.82	5.98	5.89
Romania	5.37	5.34	4.31	5.02	5.17	5.39	5.94	5.87	6.05	5.08
World average	5.59		4.73		7.18		4.13		6.31	

Source: World Bank.

** When data for 2005 were not available, data for 2004 were employed.*

In 2005 the KEI for Romania is slightly below the world's average (5.37 as against 5.59), the only pillar with a better score than the world's average being education (5.94 as against 4.13). With a KEI in the 5 - 6 interval, Romania has the worst performance among the EU new member states: Bulgaria apart (situated in the 6 – 7 interval), all other new member states are situated in the 7 – 8 interval, where countries like Spain, Italy and Greece are also placed. The results also confirm the leading position of Denmark and Finland which are, according to various international statistics (e.g. WEF, IMD), among world's leaders in terms of economic competitiveness as well.

Going further, Figure 2 present an overall image of the ICT Index at international level, highlighting the US and Finland as the world's leaders. Again, Romania has a backward position, with a normalized score slightly above 6 in 2005. However, compared to the KEI, the ICT Index suggests a better situation and a contribution to the KEI higher than the other components.

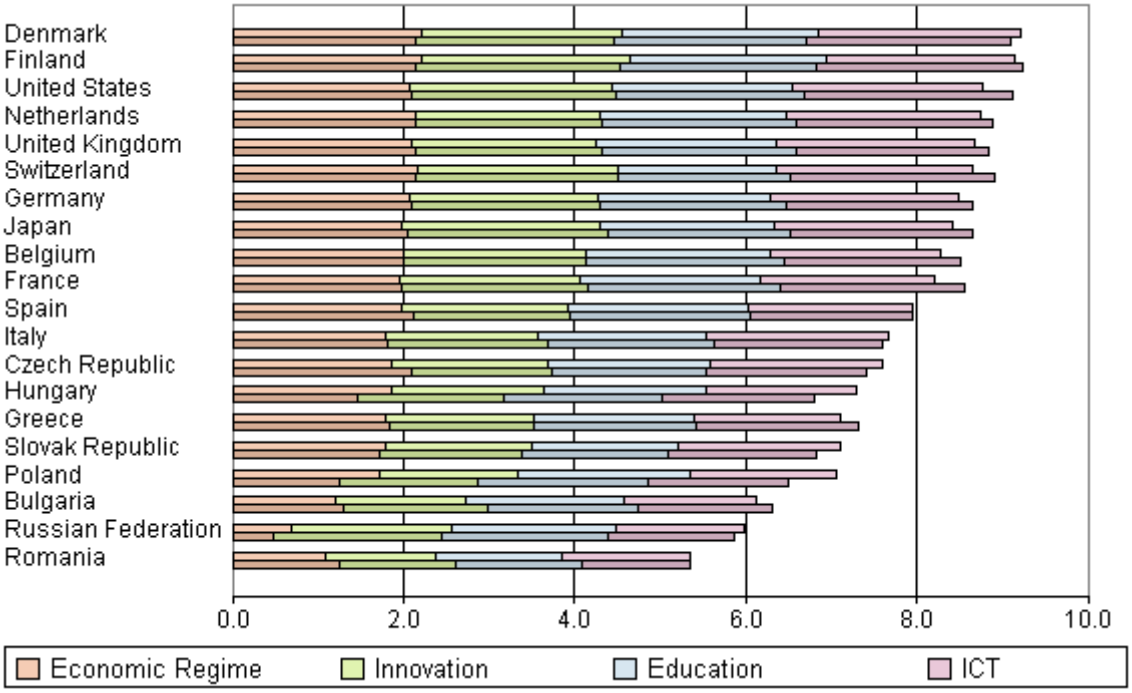

Fig.1. Knowledge Economy Index in 1995 and most recent year*

**2004 or 2005 for most of the variables*

Source: data from Table 1.

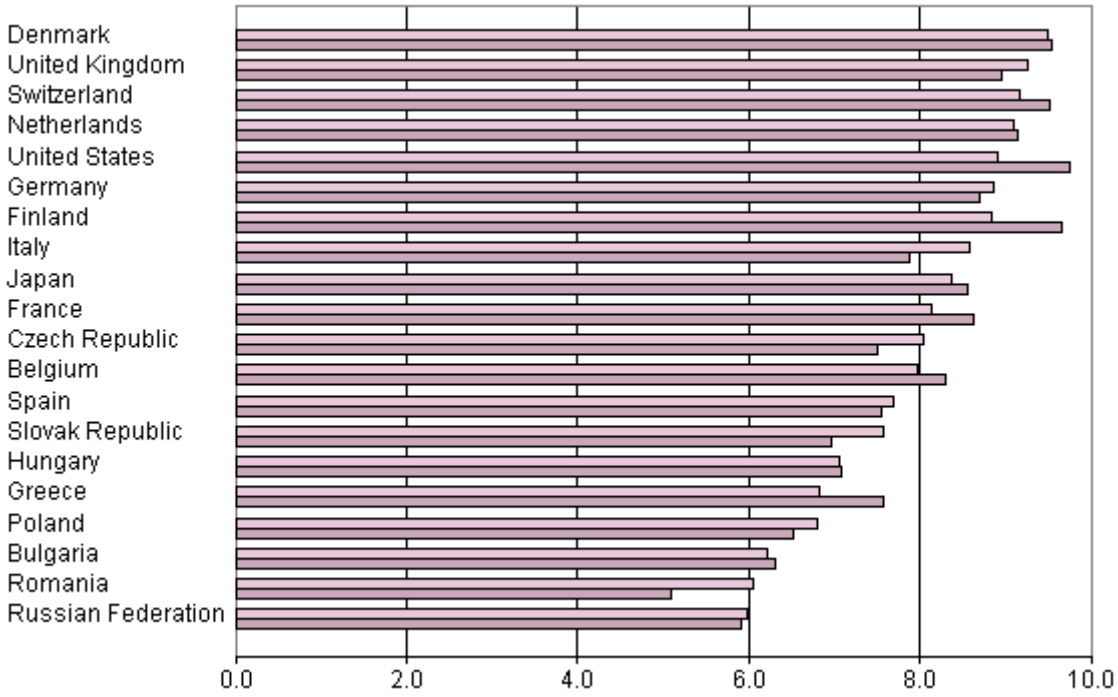

Fig.2. ICT index in 1995 and most recent year available

Source: World Bank.

An analytical view (Table 2 and Figure 3) reveals the better records for Romania in relative terms for internet users per 1000 people, international internet bandwidth, mobile phones per 1000 people and computers per 1000 people.

Table 2. ICT variables for Romania

Variable	Romania	
	actual	normalized
Tariff & Nontariff Barriers (0-5), 2006	3.50	2.56
Total Telephones per 1,000 People, 2004	673.50	5.91
Main Telephone Lines per 1000 People, 2004	202.40	5.38
Mobile Phones per 1,000 People, 2004	471.10	6.14
Computers per 1,000 People, 2004	113.00	5.87
Households with Television (%), 2004	86.60	4.39
Daily Newspapers per 1,000 People, 2000	n/a	n/a
International Internet Bandwidth (bits per person), 2004	186.00	5.91
Internet Users per 1,000 People, 2004	207.50	6.36
Price Basket for Internet (US$ per month), 2003	26.40	4.17
Availability of e-Government Services (1-7), 2006	3.26	4.45
Extent of Business Internet Use (1-7), 2006	3.20	3.45
ICT Expenditure as % of GDP, 2005	3.61	1.89

Source: World Bank.

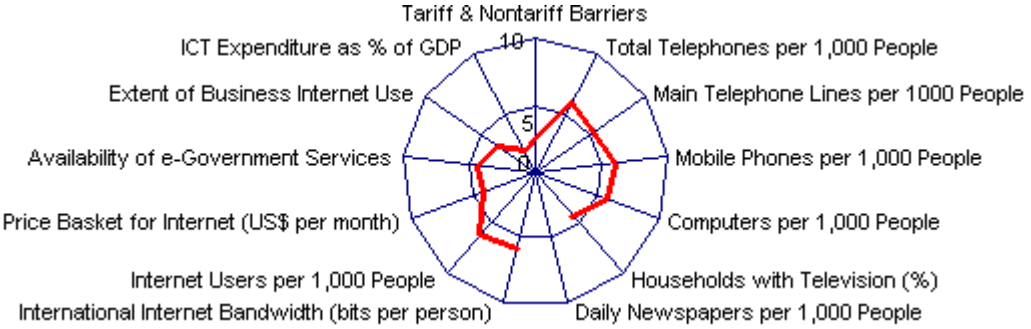

Fig.3. The ICT index for Romania
Source: World Bank.

The basic scorecard for Romania, including only 12 variables, as mentioned before, demonstrates the country progresses in 2005 as compared to 1995 (Table 3 and Figure 4) in terms of GDP annual growth rate, tariff and non-tarriff barriers, scientific and technological journals and articles per 1 million people, gross tertiary enrollment, total telephones per 1000 people, computers per 1000 people and internet users per 1000 people – all as actual values. Though, when the normalized score is calculated, from the above mentioned indicators the GDP annual growth rate and tariff and non-tarriff barriers display a worse situation in 2005 as against 1995. For both actual and normalized values the indicator "researchers in R&D per 1 million people" recorded a serious drop in 2005 as against 1995, while the number of patents granted by USPTO per 1 million people displays a lower score in 2005, despite the slights increase in actual terms.

Table. 3. The Basic Scorecard for Romania in 1995 and 2005

Variable	Romania 2005		Romania 1995	
	actual	normalized	actual	normalized
Annual GDP Growth (%)	5.70	5.19	2.12	5.56
Human Development Index	0.792	5.00	0.772	5.00
Tariff & Nontariff Barriers	3.50	0.38	1.50	8.46
Regulatory Quality	0.17	5.56	-0.59	3.70
Rule of Law	-0.29	5.56	-0.34	5.19
Researchers in R&D / Mil. People	976.00	2.17	1343.52	4.35

Variable	Romania 2005		Romania 1995	
	actual	normalized	actual	normalized
Scientific and Technical Journal Articles / Mil. People	45.53	4.07	28.55	3.33
Patents Granted by USPTO / Mil. People	0.34	3.70	0.10	4.81
Adult Literacy Rate (% age 15 and above)	97.30	1.48	97.60	2.40
Gross Secondary Enrollment	85.10	2.69	77.90	2.31
Gross Tertiary Enrollment	40.20	4.62	18.00	1.15
Total Telephones per 1,000 People	673.50	4.44	131.30	3.33
Computers per 1,000 People	113.00	5.22	13.20	4.00
Internet Users per 1,000 People	207.50	5.93	0.70	4.81

Source: World Bank.

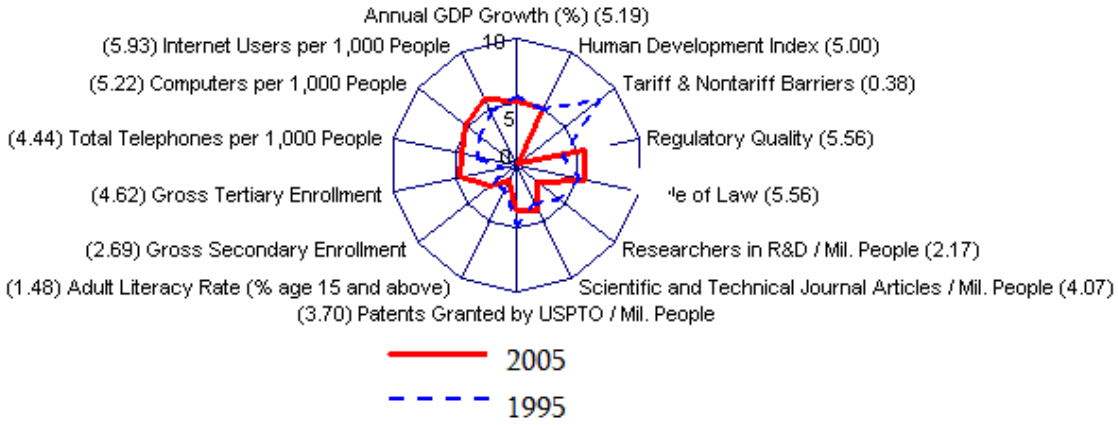

Fig.4. The Basic Scorecard for Romania in 1995 and 2005
Source: World Bank.

Conclusions. At present ICT is largely acknowledged as the backbone of the knowledge economy, all economic strategies addressing it as an effective solution for promoting economic growth and sustainable development. Consequently, at international level there is a great interest in developing indicator systems and methodologies able to characterize the multiple dimensions of the knowledge economy and ICT, as a background for underlying effective strategies and policies in these fields.

Starting from the data provided by the World Bank statistics and using the World Bank Institute methodology for Knowledge Economy Index and ICT Index, our paper has presented and discussed Romanian position and progress in ICT in a larger international context.

The results point out a pretty weak position of Romania, despites the progress recorded especially in terms of scientific and technological journals and articles per 1 million people, gross tertiary enrollment, total telephones per 1000 people, computers per 1000 people and internet users per 1000 people. The results also suggest the need of a particular emphasis on the R&D policy, considering the completely unsatisfactory records for very important indicators such as "researchers in R&D per 1 million people" and "the number of patents granted by USPTO per 1 million people".

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