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Designing a Model of System Dynamics (SD) on the Policy of Upgrading Indices of Iran ICT Network

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Abstract: In the recent years, developments in the field of information and telecommunication are pursued by major changes in different areas of human life. Human has constantly employed the technology and track record of human life is abundant with innovation in Information and Communication Technologies (ICT) which are called as new or high-technology. Therefore, Information and communication technology Development Indices (IDI) are remarkably important. This research purports to design a model of System Dynamics (SD) on the policy of upgrading indices of Iran ICT network. Accordingly, after investigating the IDI and mining the indices, the causal loops and flow chart are depicted through using the SD (System Dynamics). The results of simulation show that, the behavior of studied key variables, after performing enhancing economic growth policies, improved the quality and quantity of ICT infrastructure, social indices, the culture of employing ICT and the technical knowledge of ICT operators and the enhancing process has accelerated.

Key words: Information and Communication Technologies (ICT), Information and communication technologies Development Indices (IDI), System Dynamics (SD), designing, model

INTRODUCTION

Human life has improved from mass production era to information and telecommunication era and evolution of countries towards information and knowledge-based societies has affected all the processes and financial, cultural, industrial, political and social interaction activities. The structural framework of this era is information and telecommunication production, process, transfer and management in order to setting up individual, group, organizational, national and international science and knowledge bases. Therefore, it expresses the Information Technology (IT) which includes the applied techniques in the so-called process as a vital and determining factor. Public knowledge and awareness growth and all-out spreading changes in the national societies and world are getting faster, vaster and more intensive. The world development trend has passed the industrial era and is entering the post industrial era, informational society, knowledge management, telecommunication globalization and information explosion. IT has become applicable in all the social, economical, cultural and management systems and advocate of development in service and technology based systems in virtual and non-virtual environments. This new fangled and general technology has played an important role in enhancement and transparency of information and, it is considered as an effective factor on improving the standard of living, public welfare, truthfulness and social justice so that, effects and consequences of its application has leaded to acceleration of economic and social growth rate in developed countries. Developing countries, also have a positive attitude towards the application of this technology in various aspects, however, the distance of information and science gap in these societies compared to the developed countries is increasing.

In today's world information is not only known as one of the main sources and possessions of the organizations but also, considered as medium and means to manage other sources and possessions of the organizations, efficiently. Thus, it is of particular importance and value. However, this method is accessible and realistic only if the information is presented to the beneficiaries at a convenient time with desired quality and acceptable security and telecommunication runs optimally and desirably. Hence, IT which underlies effective date transfer, exchange, application and management in countries is of vital importance.

It is estimated that the number of connected devices to the Internet reach to 40 billion by 2020. Research has shown that the proportion of Information and

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Communication Technology (ICT) in the total output growth has increased from the average of 6.4% during 1990-1995 to 11.8% during 1995-2000 which has approximately duplicated and the IT investment has a clear causal effect on the economic growth (Khuang, 2004). Moreover, during 1989-1995 and 1995-2003, the most beneficiary group of ICT are the countries associated with the Group of Seven (G7) which who believe 27% of their Gross Domestic Product (GDP) is affected by ICT during 1995-2003 (Jorgensen and Stiroh, 2000). Therefore, there is a strong bound between ICT and economic growth (Erbicam, 2005) and ICT expenses have a positive correlation with economic growth (Nour, 2002; Nasiri and Goodarzi, 2005).

Although, IT effects on education approaches, medical, electronic governmet, electronic commerce, electronic banking, telecommuting and electronic conference, also the significance of ICT is obvious as one of the basic substructures of development. Hence, IT accomplishments has resulted in a new gap and deepened the previous injustice. Digital gap or injustice in access and usability of ICT has resulted in the accelerated development of a part of the world and lagging behind the other part.

Although, in the world ranking, Iran in some fields such as science production growth, the number of published books, natural gas production, agricultural production and cement production is in an accepted level, unfortunately, in the field of ICT, in spite of its potentials is not in a decent position, in a way that, in terms of the digital opportunity indices, Iran is ranked 105, the electronic government readiness is ranked 102 and the number of Internet hosts is ranked 120. Also, the Internet speed in Iran is ranked 174 among 181 countries (ITU, 2011).

Therefore, considering the unbalanced indices of ICT in Iran which holds its own economic and social consequences, the main purpose of this study is presenting a model to improve ICT indices. Regarding that, the system dynamics approach can effectively show the effect of economic, social and technical issues feedback on ICT indices. As a result, the present study utilizes the so-called approaches. Through, dynamic simulation of the information technology indices, a precise image of the process of index changes in the past and its scientific estimation in future will be presented and based on that, it would be possible to predict the possibility of performing different policies and investigating the results of the performance on ICT indices.

Literature review: In this study, in order to identify indices of ICT, we study different models which are presented in this field.

Information and communication technology Dvelopment Indices (IDI): IDI is a set composed of 11 indices purporting to monitoring and comparing the level of growth and development of different countries in the field of information and communication technologies. These indices were designated by the international telecommunication union in 2008 and were published in 2009 for the first time. The noticed indices in this model are accessibility index, usage index and skill index (ITU, 2011).

The Digital Opportunity Index (DOI): Digital opportunity index is a tool which has been designed to investigate the level of progress in bridging the digital divide and also monitoring the implementations of the decisions made by the World Summit on the Information Society (WSIS). This medium paves the way to investigate, the regional and global trends in infrastructure, opportunities and also application and usage of ICT to form an information society. Digital opportunity indices are in three general categories of opportunity, infrastructure and usage.

Networked readiness index of world economic forum: Networked Readiness Index (NRI) was proposed in 2002 for the first time by world economy forum in the field of IT and the indices were completed gradually through passing time. The extensive report of the major indices and sub-indexes are presented annually. The noted indices in this model are as follows: the political and regulatory environment, the business and innovation environment, the infrastructure and digital content, the affordability, the skills, the individual usage, the business usage, the government usage, the economic impacts and the social impacts (WITSA, 2003).

EIU indices: EIU (Economist Intelligence Unit) has published the annual report of networked readiness from 2000. This ranking is about technical, economic, political and social issues of 68 countries. The noted indices in the so-called model are as follows: consistency and infrastructure technology, business environment, commercial admission and consumers, the political and regulatory environment, social and cultural environment, supporting electronic services.

Digital divide measuring model: Through, investigating different resources and references which proposed the elements and indices of digital divide, a comprehensive conceptual model has been presented in this regard. According to this model, main indices and sub-indexes of digital divide are as follows: access to infrastructures, cost, usage, social and government obstructions/ supports, possibility of accessibility (Cilan *et al*., 2009).

Electronic government development index: According the definition given by UNDESA institute in 2012, development of electronic government criteria are categorized into three subgroups as follows: online services, telecommunication infrastructures, human capital.

OECD Index: The manual of measuring information society which is presented by OECD provides a standard reference for actuaries, analysts and decision makers in ICT. This manual summarizes, the statistical definitions and standards proposed by of information society working group indices in order to be aware of activities of telecommunication, computer and information policy committee. This manual was published for the first time in 2005 and is updated biennially to review the changes in information society and its gratitude. The proposed indices in this model include major indices of ICT infrastructure and accessibility, major indices of accessibility and applicability of ICT by users and families, major indices in ICT production section and trading ICT goods, major indices of ICT in education.

Getting ready for networked world: Center for International Development of Harvard University has prepared a flexible and systematic approach to measure networked readiness. This manual is a systematic medium which is organized to measure numerous factors of representing networked readiness in developing societies. The noted indices in this model are: accessibility of network, learnability of network, networked society, networked economics, networked policy Press *et al*., 1998; Sachs, 2000).

SIBIS index: This manual aims to develop the fundamental data through suggesting main elements of an index system on one of the profound inventions of technology in the recent decades that is to say, computerized networks generally and the Internet specifically. The noted indices in this model include ICT infrastructures, accessibility to ICT indices, accessibility to website (Consortium, 2003).

Digital Access Index (DAI): This index is designed to measure the overall ability of individuals in a country to access and use ICT. Digital access index is based on five basic factors which effect on ICT accessibility. These factors are as follows: infrastructure, affordability, knowledge, quality and actual usage.

McConnell International E-readiness (MI): E-readiness determines and evaluates the capacity of nations to contribute in the global digital economy. However, this will be important when we consider world economy growth is growingly dependant on ICT and countries and organizations ability to collect, process and use of digital information. Therefore to flourish business and societies economy, it is necessary to reach an advanced government in E-readiness. The proposed indices in this model are: connectivity, E-leadership, information security, human capital and E-business climate.

Mosaic index: This model has presented a comprehensive framework for internet diffusion in a country. This framework includes six dimensions with definite details and how they are applied. The noticed indices in this model are: internet diffusion and pervasiveness, geographic dispersion, Internet diffusion in different sections, connectivity infrastructures, organizational infrastructure and Internet use gradual development.

E-readiness CSPP index: This manual prepares a self-evaluating tool to help the societies to assess their readiness to contribute in the networked world. The noticed indices in this model are as follows: network (infrastructure), networked locations (accessibility), networked services and applications, networked economy, networked world enablers.

WITSA index: This report covers 75 countries which are the biggest customers of ICT. This report estimates the costs and expenses of ICT in 14 nationally industrial sections together with consumer expenses in four groups of hardware, software, service and communication. Some of the noticed indices are as follows: ICT costs in terms of world, ICT costs in terms of region, ICT costs terms of technology (WITSA, 2008). Investigating the above mentioned models, a set of indices of information and communication technologies are identified based on Table 1.

Table 1: Information and communication technologies Indices

Index	IDI	DOI	NRI	EIU	DD	EGDI	OECD	CID	SIBIS	DAI	MI	Mosaic	CSPP	WITSA
International bandwidth diffusion factor	✓			✓			P	✓	✓	✓	✓	✓	✓	
Adult literacy rate	✓		✓			✓	✓	✓	✓	✓	✓			
The number of stages and processes needed for starting a business			✓	✓				✓	✓					
Free business environment for trading and investing				✓				✓						
Power generation rate			✓				✓				✓			
Political tendency to privatization				✓	✓									
Mutual funds possibility			✓					✓			✓			
International internet bandwidth			✓				✓	✓	✓	✓	✓	✓	✓	
Government support of infrastructures and Internet readiness effectiveness of traditional frameworks				✓				✓	✓		✓	✓		
Rights and regulatory system efficiency in solving disputes and problems			✓	✓				✓						
Government preparation for advanced technology ✓roducts			✓					✓	✓		✓			
Time needed to sign contract			✓								✓			
Political stability				✓					✓					
Cable internet tariff		✓	✓				✓	✓		✓	✓			
Internet literacy and skillfulness				✓			✓	✓	✓	✓	✓			
Mobile network coverage			✓				✓	✓	✓		✓			
Government approach to digital innovation grants				✓					✓		✓			
Commercial use of internet			✓	✓			✓	✓	✓		✓	✓	✓	
Safe Internet servers			✓					✓	✓		✓			
Mobile tariffs and usage cost		✓	✓				✓	✓		✓	✓			
Investment and funding					✓			✓						
Local (internal) competitiveness			✓	✓				✓	✓				✓	
Age					✓							✓		
Tax rate			✓	✓										
Market				✓				✓						
Customer access to after sale service				✓									✓	
Time needed to start a business			✓					✓	✓		✓			
Infrastructure quality				✓				✓	✓	✓	✓	✓	✓	
Rights and regulatory system efficiency in challenging the regulations			✓	✓				✓	✓					
Online time					✓			✓			✓			
Internet and telephone competitiveness index			✓					✓	✓				✓	
The number of procedures to sign a contract			✓					✓						
Financial power				✓				✓						
Access to digital content			✓		✓			✓	✓					
Content cost					✓			✓			✓			
Computer fraud and deceives			✓					✓	✓		✓			
Mental power support			✓								✓		✓	
Education system quality			✓		✓		✓	✓	✓	✓	✓			
Social status					✓			✓						
Judicial dependence or independence			✓					✓						
Legislative effectiveness			✓					✓						
Narrowband diffusion				✓			✓	✓						
Using Internet and government efficiency			✓				✓	✓	✓		✓	✓	✓	
Using virtual social networks			✓		✓			✓	✓			✓	✓	
Broadband diffusion				✓			✓	✓	✓	✓				
Information and communication technologies importance in government future prospective			✓				✓	✓			✓			
Giving priority to information and communication technologies by government			✓					✓			✓			
Users technical skillfulness in the field				✓	✓			✓	✓	✓	✓			
The effect of information and communication technologies on access to basic services			✓					✓						
The effect of information and communication technologies on access to new products and services			✓					✓						
The effect of information and communication technologies on access on organizational models and patterns			✓								✓			
Recruitment percentage in knowledge activities (requiring alot of knowledge)			✓					✓						
Family access percentage to Internet network	✓	✓	✓				✓	✓	✓	✓	✓	✓	✓	
Family access percentage to computer	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	
Internet subscription percentage	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	
Cable Internet subscription usage percentage	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	
Mobile Internet subscription percentage		✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	

Table 1: Continue

Index	IDI	DOI	NRI	EIU	DD	EGDI	OECD	CID	SIBIS	DAI	MI	Mosaic	CSPP	WITSA
Mobile internet subscription percentage	✓	✓	✓			✓	✓	✓	✓		✓	✓	✓	
Internet access in schools			✓				✓	✓	✓		✓		✓	
Access to latest technology			✓								✓			
Staff training level			✓	✓	✓		✓	✓	✓	✓	✓			
Government's online service index			✓			✓	✓	✓	✓		✓	✓		
Skillfulness and innovation capacity			✓	✓							✓		✓	
Rules and regulations related to information and communication technologies			✓					✓						
Technology attraction and acceptance in company level			✓					✓						
Third grade graduates rate	✓		✓			✓			✓		✓			
Cable telephone diffusion factor	✓	✓				✓	✓		✓	✓	✓	✓	✓	

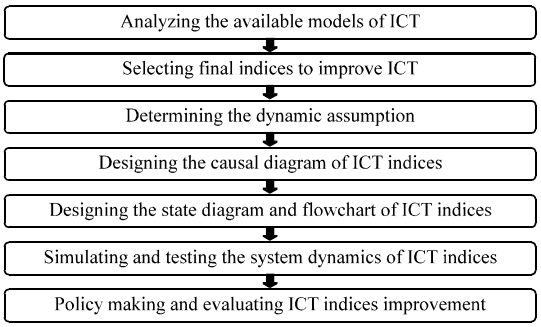

Fig. 1: Research process

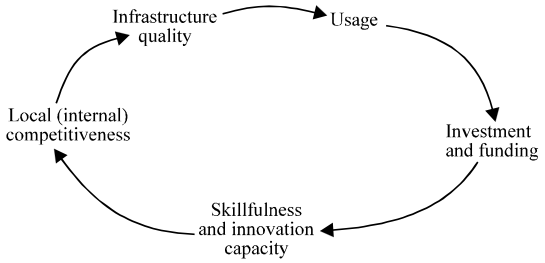

Fig. 2: Dynamic hypothesis

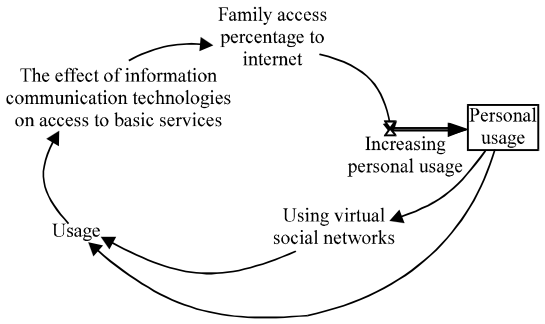

Fig. 3: Personal usage

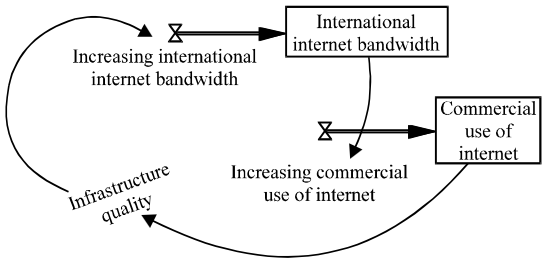

Fig. 4: Commercial usage

MATERIALS AND METHODS

The present study purports to be practical and it is explanatory and casual by nature. Also, based on the available data, it is considered as a quantitative research and in terms of data collection, it is a documentary research. The statistical society in this study is composed of organizations, institutions and ICT service givers and service receivers in Iran. Regarding the type and methodology used in this study, sampling of statistical society was not needed. In this study, using causal diagram, flowchart and state diagram, the data was analyzed by Vensim software. Besides, the data collection tool was the documentary resources acclaimed by annual reports of international telecommunication union, the world economic forum and ministry of information and communications technology of Iran. The main stages followed in this study are shown in Fig. 1.

After identifying the information and communication technologies indices, the main casual loop, which is based on dynamic assumption, is considered as the following shown in Fig. 2.

RESULTS AND DISCUSSION

Results obtained from designing a casual loop are depicted in Fig. 3-11.

Stock and flow diagram: After designing the casual loops, the flowchart of information and communication technologies indices model is illustrated in Fig. 11.

Results of validating the model: In order to validate the designed model, different test were applied whose results will be presented in the following.

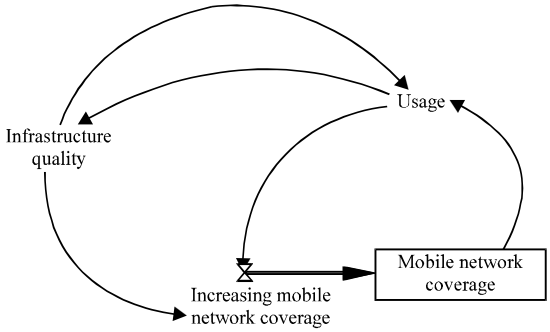

Fig. 5: Mobile network coverage

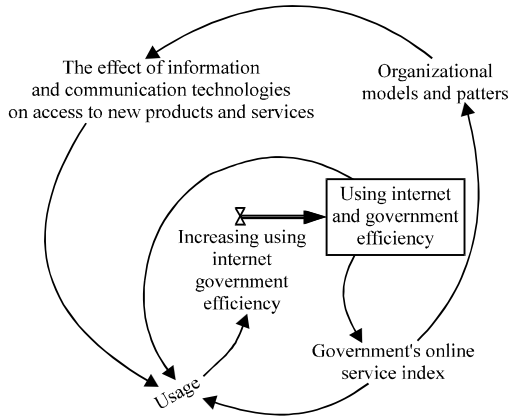

Fig. 6: Government usage

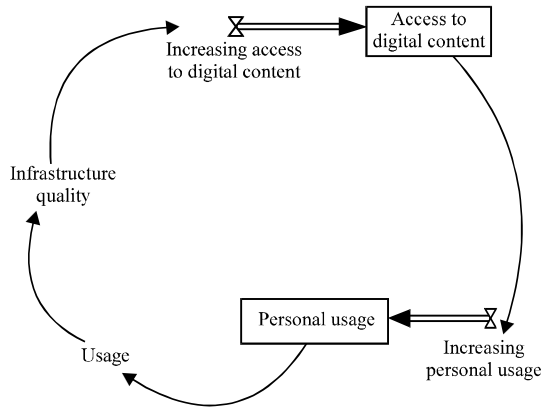

Fig. 7: Access to digital content

Boundary conditions: This test shows the elasticity of the model in major changes. According to the results of variables behavior simulation in boundary conditions tending to zero and infinity, variables behavior was logical and the model has functioned properly in an acceptable range.

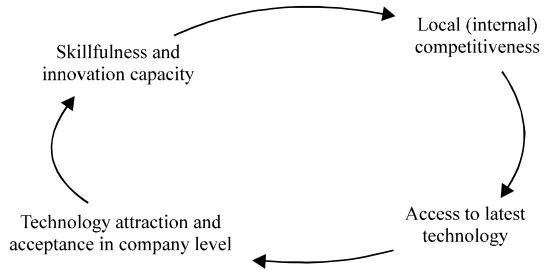

Fig. 8: Innovation and technology

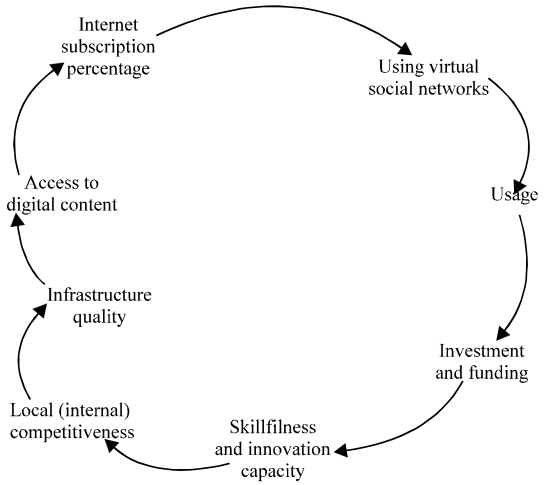

Fig. 9: Investment and funding

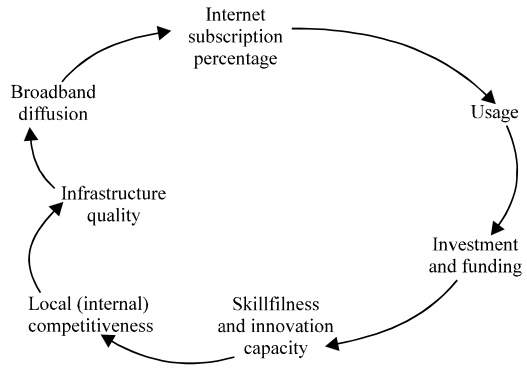

Fig. 10: International bandwidth

System improvement: This test investigates whether the policies into practice were useful and has improved the system behavior. Comparing the variables behavior before and after putting them into practice, it is recognizable that all variables behavior is improved by the policies in practice. Consequently, the policies were positively effective.

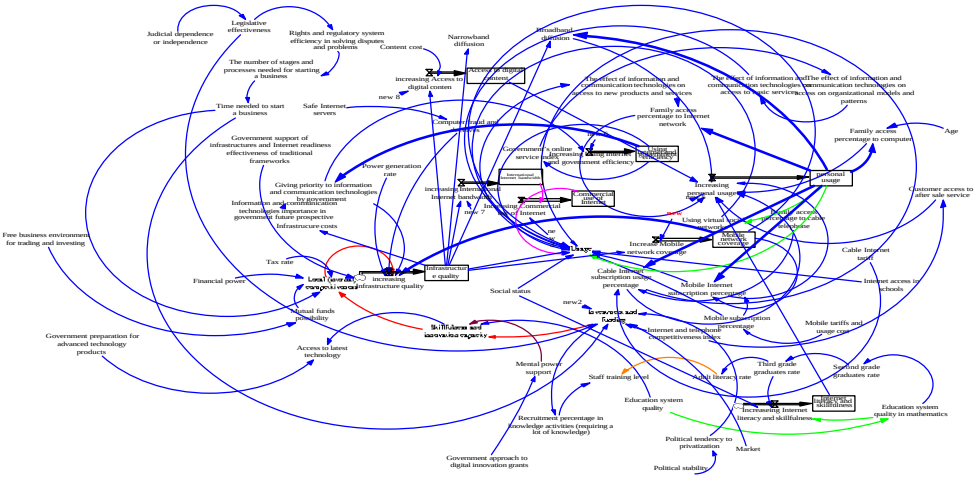

Fig. 11: Stock and flow diagram

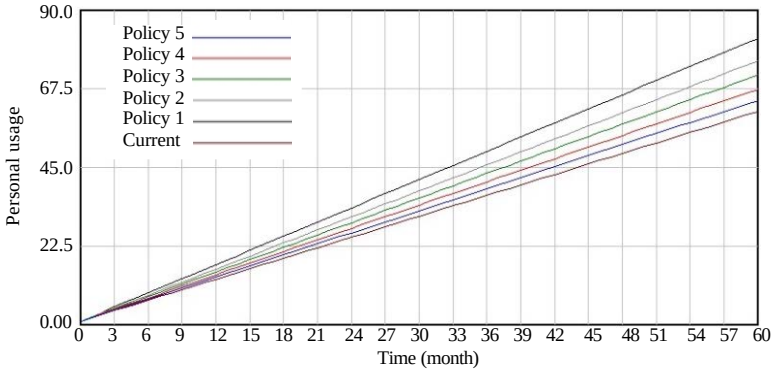

Fig. 12: Personal usage simulation

Face validity: This test analyses the model based on the visual aspects and seeks to investigate whether the model structure is similar to real system and whether it represents the real model. The model of system dynamics of information and communication technologies indices is designed based on extracted indices from valid ICT models. Also, the connections between indices are determined based on consistency regards and direct observation. Accordingly, it can be claimed that the presented model is reflecting a real model.

Boundary efficiency: This test seeks to check the appropriateness of variables and model structure to the subject in question and to reproduce the variables original behavior. Since, the model of system dynamics of information and communication technologies indices is designed based on extracted indices from valid ICT models, the appropriateness of variables and model structure is verified. Moreover, variables behavior prior to putting the policies into practice represents the current situation.

Abnormal behavior: This test studies the divergence of the model behavior and real system. The results of simulation of system dynamics of information and communication technologies indices shows that the variables behavior under question is in co-ordinance with the reality and no behavior diverging the reality was not observed.

Congruence on audience: This test examines the appropriateness of simplicity and complexity of model and the level of its generalizability of the designed model. Regarding that the designed model is based on extracted indices from selected and valid of information and communication technologies models. Therefore, maximum variables associated with the subject are embedded in the model and it is acceptably detailed.

Results of simulation of dynamics of information and communication technologies indices: In this study, the results of simulation of dynamics of information and communication technologies indices before and after putting the policies into practice are depicted in Fig. 12-19. The evaluated policies are as follows:

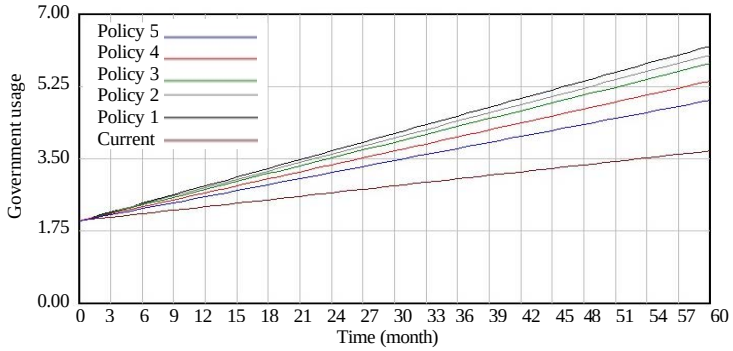

Fig. 13: Government usage simulation

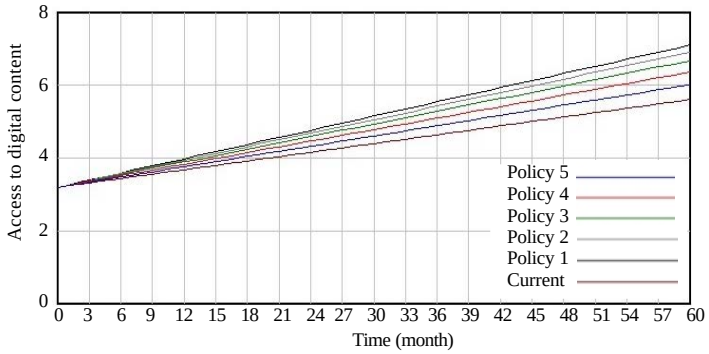

Fig. 14: Access to digital content simulation

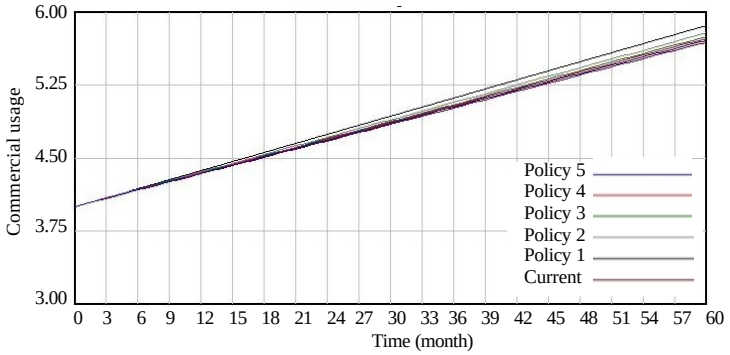

Fig. 15: Commercial usage simulation

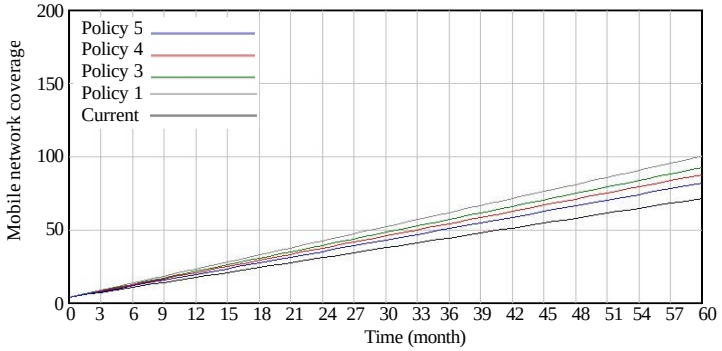

Fig. 16: Mobile network coverage simulation

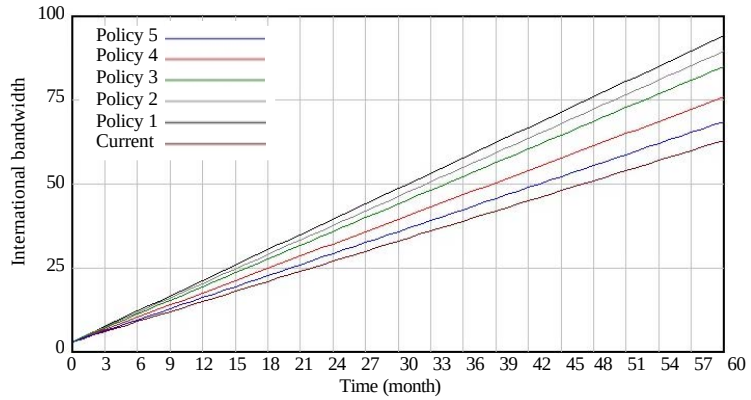

Fig. 17: International bandwidth simulation

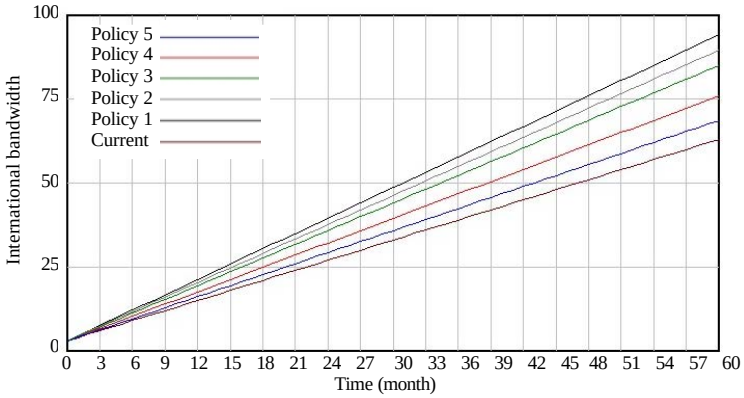

Fig. 18: Infrastructure quality simulation

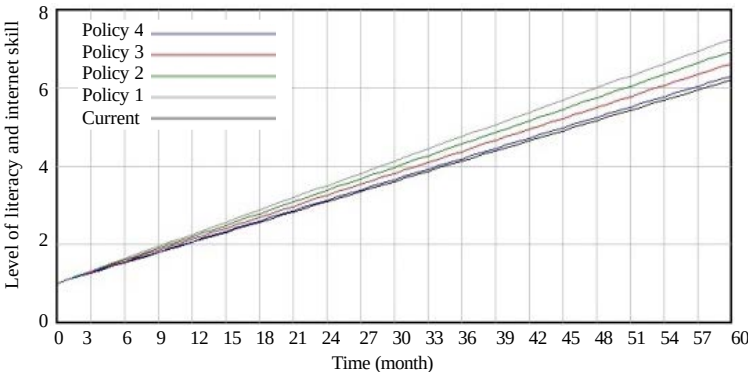

Fig. 19: Level of literacy and internet skill simulation

CONCLUSION

The results of simulation before and after putting the policies into practice show that the policy of economy growth (GDP) has affected the Internet-usage by the government more than other policies. The policy of improving quality and quantity of ICT infrastructure was of the secondary importance. Besides, the policy of social indices growth (such as education, welfare, life quality and health) was the second effective policy on the Internet-usage by the government, after improving quality and quantity of ICT infrastructure. Moreover, the policy of improving the culture of employing ICT (e.g. advertisement, simplification and obligation to use) has increased the Internet usage by the government more than the policy of improving users' ICT technical knowledge.

According to the results of simulation before and after putting the policies into practice, it appears that the policy of economy growth (GDP) is influential on the personal usage of the Internet more than other policies. The policy of improving quality and quantity of ICT infrastructure was of the second most influential policy and the policy of social indices growth (such as education, welfare, life quality and health) after improving quality and quantity of ICT infrastructure was the second effective policy on the personal Internet-usage. Moreover, the policy of improving the culture of employing ICT (e.g. advertisement, simplification and obligation to use) on personal Internet- usage was more effective than the policy of improving users' ICT technical knowledge.

The results of simulation before and after putting the policies into practice reveals that the policy of economy growth (GDP) significantly effects on the commercial usage of the Internet, more than other policies. The policy of improving quality and quantity of ICT infrastructure was ranked the next. Moreover, improving quality and quantity of ICT infrastructure and the policy of social indices growth (such as education, welfare, life quality and health) are the most effective policies on the commercial usage of the Internet, respectively. In the same way, the policy of improving the culture of employing ICT (e.g. advertisement, simplification and obligation to use) on commercial usage of the Internet was more effective than the policy of improving users' ICT technical knowledge.

The outcomes of simulation before and after putting the policies into practice demonstrate that the policy of economy growth (GDP) is the first most decisive policy on the access to digital content. And the policy of improving quality and quantity of ICT infrastructure is ranked the second. Also, the policy of improving quality and quantity of ICT infrastructure, social indices growth (such as education, welfare, life quality and health), the policy of improving the culture of employing ICT (e.g., advertisement, simplification and obligation to use) and the policy of improving users' ICT technical knowledge enhance the access to digital content, respectively.

The results of simulation before and after putting the policies into practice show that the policy of economy growth (GDP) has increased the International Internet bandwidth more than other policies. The policy of improving quality and quantity of ICT infrastructure was of the secondary effective policy. Besides, the policy of social indices growth (such as education, welfare, life quality and health) was the second effective policy on the International Internet bandwidth, after improving quality and quantity of ICT infrastructure. Moreover, the policy of improving the culture of employing ICT (e.g. advertisement, simplification and obligation to use) has increased the International Internet bandwidth more than the policy of improving users' ICT technical knowledge.

According to the results of simulation before and after putting the policies into practice, it appears that the policy of economy growth (GDP) is influential on the network coverage more than other policies. The policy of social indices growth (such as education, welfare, life quality and health) is the next effective policy on network coverage. Likely, the policy of improving the culture of employing ICT (e.g. advertisement, simplification and obligation to use) enhances network coverage more than the policy of improving users' ICT technical knowledge.

The results of simulation before and after putting the policies into practice reveals that the policy of economy growth (GDP) significantly effects on the level of literacy and internet skill, more than other policies. The policy of improving quality and quantity of ICT infrastructure was ranked the next. Moreover, improving quality and quantity of ICT infrastructure and the policy of social indices growth (such as education, welfare, life quality and health) are the most effective policies on the level of literacy and internet skill, respectively. In the same way, the policy of improving the culture of employing ICT (e.g. advertisement, simplification and obligation to use) on level of literacy and internet skill was more effective than the policy of improving users' ICT technical knowledge.

The outcomes of simulation before and after putting the policies into practice demonstrate that the policy of economy growth (GDP) is the first most decisive policy on improving the infrastructure quality. Also, the policy of social indices growth (such as education, welfare, life quality and health) is the next. Plus, the policy of improving the culture of employing ICT (e.g., advertisement, simplification and obligation to use) and the policy of improving users' ICT technical knowledge enhance the network coverage, respectively.

As the simulated behavior of variables after policies put into practice exhibits, putting different policies into practice accelerates the rate of variables growth and the optimum time would be shorter. Accordingly, we can conclude that the policies put into practice were effective and improve the system.

REFERENCES

Cilan, C.A., B.A. Bolat and E. Co°kun, 2009. Analyzing digital divide within and between member and candidate countries of European Union. Government Inf. Q., 26: 98-105.

Consortium, SIBIS., 2003. SIBIS: New eEurope Indicator Handbook. Empirica, Bonn, Germany,.

ITU, 2003. World Telecommunication Development Report 2003: Access Indicators for the Information Society. 7th Edn., International Telecommunication Union, India, Pages: 149.

Jorgenson, D.W. and K.J. Stiroh, 2000. US economic growth at the industry level. Am. Econ. Rev., 90: 161-167.

Nasiri, F. and A. Goodarzi, 2005. ICT and economic growth in selected countries: Panel data method. J. New Econ., 1: 73-94.

Nour, O.M., 2002. The impact of ICT on economic development in the Arab world: A comparative study of Egypt and the Persian Gulf countries Institute for New Technologies (INTECH), The United Nations University (UNU), Shibuya, Japan.

Press, L., G. Burkhart, W. Foster, S. Goodman and P. Wolcott, *et al*., 1998. An internet diffusion framework. Commun. ACM., 41: 21-26.

Sachs, J.D., 2000. Readiness for the Networked World: A Guide for Developing Countries. Center for International Development, Harvard University, Cambridge, Massachusetts,.

WITSA, 2008. Digital planet 2008: The global information economy. WITSA, Arlington, Virginia.