**A Multi-sector ICT Economy**

**Interaction Model for Egypt**

**“ The Path to Information Society”**

Professor Motaz Khorshid

Cairo University

Former Minister of Higher Education

& State for Scientific Research

motaz.khorshid@gmail.com

Asaad El-Sadek

Ph.D. Student

Faculty of Computers & Information

Cairo University

aelsadek\_2006@yahoo.com

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**Introduction**

Several economists, engineers and computer scientists argue that the progress in ICT would significantly improve human resource indicators, enhance the productivity of various economic sectors and increase the welfare level of citizens. They generally concluded that ICT is currently becoming a prerequisite and a critical factor in achieving sustainable socioeconomic development. These are generally accepted arguments given the dominating trend towards the knowledge economy in the twenty first century. This Hypothesis needs nevertheless to be tested using advanced analytical tools – or models – in order to estimate the overall socioeconomic impact of the ICT sector as well as its interaction with the rest of the production activities. This would necessarily require the development and implementation of an enhanced socioeconomic database coupled with an extended computational model.

In recognition of the important role of information and communication technology (ICT) in transforming developing countries into modern knowledge societies in the 21st century, the government of Egypt has developed both medium and long-term sector specific plans. The rapid spreading out of ICT services in Egypt and the need to assess its economy wide impact, has triggered a demand for an issue-oriented ICT-based social accounting matrix (SAM) and ICT economy wide interaction modeling tools. The constructed issue-specific SAM serves as a consistent and a comprehensive accounting framework whereas the ICT economy interaction models are developed to capture the interaction within the Egyptian Economy with a special emphasis on the role and contribution of the ICT sector in the economy.

In Egypt, total ICT turnover reaches EGP 46.7 Billion in 2007-2008. The gross value added of the sector at current prices is EGP 31.7 Billion in the same year with an annual growth rate of 7.1 percent, which is higher than the average growth of the Egyptian economy. As a percent of Egypt’s GDP, ICT sector accounts for around 3.6%. ICT is viewed as a capital-intensive sector. As a percent of ICT value added, the operating surplus reaches 79.6%. Furthermore, its gross saving represents around 48% of the total income of the sector which is – by all means- a significant saving rate. Household spending on ICT accounts for 12% of aggregate private income. Finally, investment expenditure directed to the ICT sector is only 6.3 percent of total gross fixed capital formation. The considerable growth of the ICT sector in Egypt over the last decade coupled with its country wide dissemination, necessitates a shift in focus from making the technology work and keeping it working (operations) to understanding, predicting and influencing the contribution of ICT on individuals, organizations and the economy as a whole. In today’s knowledge society - largely dependent on ICT- it is not only just the technical dimensions of ICT that need to be considered but also the economy wide effects of ICT diffusion.

In order to address the above debate, a disaggregated issue-oriented social accounting matrix (SAM) and an extended multi-sector computable general equilibrium (CGE) model are developed and implemented in this paper. The ultimate purpose is to assess the economy wide impact of the ICT sector on the behavior of the whole economy as well as its sectors and institutions.

The disaggregated SAM and model represent an economy with eleven activities including detailed specifications of ICT sectors, five factors of production broken down by economic activity and institution, four domestic institutions and the outside world. According to the international accounting standards, ICT sector is disaggregated into seven activities: ICT manufacturing industries; ICT trade industries; software publishing; telecommunications; computer programming, consultancy and related activities; data processing, hosting and related activities; web portals and Repair of computers and communication equipment. This classification scheme is applied to the production activities and various commodity groups within the SAM or the Model. Non-ICT activities/commodities are broken down into primary production, manufacturing, productive services and social and community services. Institutions include households and unincorporated business, general government as well as ICT and Non ICT corporations. The model is composed of four groups of commodities (composite, domestic , imported and exported goods and services) with each of them broken down by type of production activity. Finally, the model includes a disaggregated capital account with investments broken down into ICT, non ICT and general government gross capital formation.

The developed analytical tool (or model) can be viewed as an extended computable general equilibrium (CGE) model with special emphasis on the ICT sector along with its role in enhancing the performance of economy and its sectors. In order to capture the impact of the ICT on the economy wide performance and growth prospects, the CGE model is used to estimate two different effects; a) the economy wide impact of ICT on the production of non ICT activities, the demand for intermediate and final consumption goods and services, the structure of labor and capital factors, the patterns of income distribution and finally the external balance with the outside world. This first type of effect is normally handled by a classical CGE model based on a SAM with disaggregated ICT sector, and b) the dynamic impact of the ICT contribution to enhancing total productivity of the economy and the efficiency of its factors of production. This long term effect is captured in the suggested ICT economy interaction model by developing a special purpose production functions that embody these overall factor productivity as well as the efficiency of each of these factors.

Based on the above orientation of the paper, the extended ICT economy interaction model was mainly used to conduct a comprehensive policy analysis exercise aiming at the investigation of alternative ICT strategies that allows Egypt to be an information-based economy and a knowledge-based society. Against this background, the government of Egypt is assumed to implement an ambitious ICT strategy composed of four policy packages directed to: (i) Increase the growth rates of gross fixed capital formation with special emphasis on ICT gross fixed capital formation, (ii) adopt various measures to increase the output, value added and factors income of the ICT activities, (iii) to implement a national training, reorientation and capacity building ICT programs to enhance factor productivity and labor efficiency of all non ICT sectors, and (iv) to apply an ICT export promotion policy.

The paper is organized around five sections. The **first** section outlines the major characteristics of the information economy. The **second** section, briefly describes the disaggregation of ICT production activities/commodities based on the concepts and methods of the revised system of national accounts (SNA), the international system of industrial classification (ISIC), harmonized system (HS) and central product classification (CPC). This section discusses also the integration of the ICT activities-commodities within the integrated SAM framework. In section **three**, the economic rationale, structure and components of a multi-sector ICT/Non ICT Social Accounting Matrix (SAM) for Egypt are briefly discussed. Based on this disaggregated SAM, the structure of the Egyptian economy and its interaction with the ICT sectors is explained. In the **fourth** section, the constructed, calibrated and validated of the disaggregated ICT economy wide interaction model is briefly described. The purpose is to introduce the specific features and economic rationale for capturing the interaction of the ICT sector of the economy as a whole and its sectors. The **fifth** section is mainly directed to using the constructed ICT economy interaction model to carry out policy experiments aiming at the estimation and isolation of the economy wide impact of the ICT sector. Finally, the **last** section summarizes the findings of our exercise and suggests a number of policy recommendations in light of the experimental results of the model.

1. **Characteristics of the information economy**

According to Godin [2008], the concept of information economy evolved from understanding of information as knowledge, to information as commodity, then information as a stage of economic development and finally information as technology.

The early definitions of the information economy focus on the production and distribution of knowledge. In this book Drucker described the difference between the manual worker and the [knowledge worker](http://en.wikipedia.org/wiki/Knowledge_worker) [Drucker, 1968]. The manual worker, according to his definition, works with his hands to produces goods or services. In contrast, a knowledge worker works with his or her head not hands, and produces ideas, information, or knowledge. Thus, from this perspective, an information economy is an economy where the proportion of labor force who are classified as knowledge workers and their contribution to the gross domestic product (GDP) are significant, important and rising over time.

The second wave of information economy definitions focused on information as commodity. Information economy is an economy where information is sold and bought like a good. As a good, information has economic value as it allows individuals to make choices that yield higher expected payoffs or expected utility than they would obtain from choices made in the absence of information.

Information economy may also be perceived as a stage of economic development coming after stages of hunting, agriculture, and manufacturing.

1. **Concepts and structure of the ICT economy-interaction SAM**

This section is the stepping-stone of this research. It explains the rationale used to identify ICT economic activities, goods and services as a first step to construct the SAM. It concentrates on explaining the approach used to incorporate ICT with in the national accounts.

***2.1. ICT economic activities***

To cope with the SNA requirements, the definition of the ICT sector included in the United Nations classification of economic activities (ISIC, Rev.4) provides the basis for defining ICT economic activities [UN, 2008]. In ISIC, Rev.4, the following general principle is used to identify ICT economic activities (or industries):

“The production (goods and services) of a candidate industry must primarily be intended to fulfill or enable the function of information processing and communication by electronic means, including transmission and display”.

The activities of the ICT sector can then be grouped into **ICT manufacturing** industries, **ICT trade** industries and **ICT services** industries. The ISIC, Rev.4 industries that comply with the above definition are presented in table (2.1).

The distinction between information technology and content and media sector in this research is explained in Table (2.1). It clearly specifies information content activities that have direct ICT association (information technology) and those which have no direct ICT association (content and media activities).

|  |
| --- |
| ICT manufacturing industries |
| 2610 | Manufacture of electronic components and boards |
| 2620 | Manufacture of computers and peripheral equipment |
| 2630 | Manufacture of communication equipment |
| 2640 | Manufacture of consumer electronics |
| 2680 | Manufacture of magnetic and optical media |
| ICT trade industries |
| 4651 | Wholesale of computers, computer peripheral equipment and software |
| 4652 | Wholesale of electronic and telecommunications equipment and parts |
| ICT services industries |
| 5820 | Software publishing |
| 61 | Telecommunications |
| 6110 | Wired telecommunications activities |
| 6120 | Wireless telecommunications activities |
| 6130 | Satellite telecommunications activities |
| 6190 | Other telecommunications activities |
| 62 | Computer programming, consultancy and related activities |
| 6201 | Computer programming activities |
| 6202 | Computer consultancy and computer facilities management activities |
| 6209 | Other information technology and computer service activities |
| 631 | Data processing, hosting and related activities; web portals |
| 6311 | Data processing, hosting and related activities |
| 6312 | Web portals |
| 951 | Repair of computers and communication equipment |
| 9511 | Repair of computers and peripheral equipment |
| 9512 | Repair of communication equipment |

 Table (2.1): ICT economic activities

***2.2. ICT manufactured goods***

The definition of ICT manufactured goods used in this research is based on the 2003 definition by the member countries of the Organization for Economic Cooperation and Development (OECD) [OECD, 2003]. Two guiding principles were used to develop the ICT good-based definition. The first guiding principle was the one used to develop the ICT activity-based definition – previously mentioned in section 1.1 of this paper. This ensures the coherence of all ICT-related definitions. The second guiding principle was to use existing classification systems in order to take advantage of existing data sets and therefore ensure the immediate use of the proposed standard. In the case of manufactured goods, the underlying system is the Harmonized System (HS) of the World Custom Organization of 2002 [UN, 2002]. This classification scheme grouped the ICT goods into the following broad categories:

1. Telecommunication equipment
2. Computer and related equipment
3. Electronic components
4. Audio and video equipment
5. Other ICT goods

|  |  |  |
| --- | --- | --- |
| **Information and content activities** | **Information Technology** | **Content and media activities** |
| **Division** | **Group** | **Class** | **Description** |  |  |
| 58 |  |  | **Publishing books** |  |  |
|  | 581 |  | Publishing of books, periodicals and other publishing activities |  |  |
|  |  | 5811 | Book publishing |  | 5811 |
|  |  | 5812 | Publishing of directories and mailing lists |  | 5812 |
|  |  | 5813 | Publishing of newspapers, journals and periodicals |  | 5813 |
|  |  | 5819 | Other publishing activities |  | 5819 |
|  | 582 | 5820 | Software publishing | 5820 |  |
| 59 |  |  | **Motion picture, video and television programme production, sound recording****and music publishing activities** |  |  |
|  | 591 |  | Motion picture, video and television programme activities |  |  |
|  |  | 5911 | Motion picture, video and television programme production activities |  | 5911 |
|  |  | 5912 | Motion picture, video and television programme post-production activities |  | 5912 |
|  |  | 5913 | Motion picture, video and television programme distribution activities |  | 5913 |
|  |  | 5914 | Motion picture projection activities |  | 5914 |
|  | 592 | 5920 | Sound recording and music publishing activities |  | 5920 |
| 61 |  |  | **Programming and broadcasting activities** |  |  |
|  | 601 | 6010 | Radio broadcasting |  | 6010 |
|  | 602 | 6020 | Television programming and broadcasting activities |  | 6020 |
| 62 |  |  | **Computer programming, consultancy and related activities** |  |  |
|  |  | 6201 | Computer programming activities | 6201 |  |
|  |  | 6202 | Computer consultancy and computer facilities management activities | 6202 |  |
|  |  | 6209 | Other information technology and computer service activities | 6209 |  |
| 63 |  |  | Information service activities |  |  |
|  | 631 |  | Data processing, hosting and related activities; web portals |  |  |
|  |  | 6311 | Data processing, hosting and related activities | 6311 |  |
|  |  | 6312 | Web portals | 6312 |  |
|  | 639 |  | Other information service activities |  |  |
|  |  | 6391 | News agency activities |  | 6391 |
|  |  | 6399 | Other information service activities n.e.c. |  | 6399 |

 Table (2.2): Information technology and content and media sector [2]

Software is only partially covered in the HS, where it is treated as recorded media, much like music or video, and is subsumed within several 6-digit HS categories. The distinction is made by type of medium rather than by type of content. The most important category recording software is 852431- Discs for laser readings systems for reproducing phenomena other than sound or image. The HS has not been designed to classify intangibles like software, but rather to classify tangible goods as they cross a border. Given that software is a core ICT commodity, it needs to be included in a classification of ICT commodities. It has been agreed that an ICT services classification is the best place to classify all software.

***2.3 ICT services***

As for ICT service products, the international standard adopted by the OECD is the UN’s Central Product Classification (CPC). OECD proposed CPC-based ICT services classification. It includes the following headings:

1. Telecommunications and program distribution services
2. Internet telecommunications services
3. Leasing or rental services concerning other machinery and equipment without operator
4. Information technology (IT) technical consulting and support services
5. Information technology (IT) design and development services
6. Hosting and information technology (IT) infrastructure provisioning services
7. IT infrastructure and network management services
8. Computer hardware servicing, repair and maintenance
9. Published software

One of the main features of this definition was to consolidate all software related products (other than custom) under a single heading of the classification. The feature was a clear departure from the current practice where software products are classified to different parts of the CPC depending on the mode of delivery. The proposed change in structure was meant to recognize the central role of software in the information economy. It also allows for a more explicit distinction based on the functionality of the software, in particular the difference between software as a productivity tool and software as educational and entertainment content (multi-media software). Such a distinction gave the option of including or excluding multi-media software from an ICT services definition. The technology-centric approach adopted for the ICT sector and goods definition implies exclusion rather than inclusion.

***2.4 Adopted methodology***

Although, the national income accounting system represents a comprehensive and consistent socioeconomic data system for recording the economic activities, some of the special nature activities – like ICT – are only partially dealt with. ICT activities were in many situations bundled with other activities. The ICT data on Gross output, intermediate consumption, taxes and subsidies on production, compensation of employees and gross operating surplus are not promptly available. Most of the data about the supply side of the ICT are generally “mixed’ or “merged” with other data. The need arises then to extract them from the data of another sector or to apply an indirect statistical estimation methods to compute their values. Furthermore, the data about ICT commodities which are produced by non-ICT economic activities was unavailable. This part was neglected because of the difficulty to be estimated for all economic activities and its relatively small weight in the GDP. Government’s budget is used to estimate government expenditure on ICT and the family expenditure survey is used to assess the proportion of total household spending directed to ICTs.

 **3. The disaggregate ICT economy interaction Social Accounting Matrix**

Table (3.1) outlines the aggregate structure and data contents of the ICT economy interaction SAM for Egypt. Despite its aggregate nature, it can capture the basic structural features and specific characteristics of the disaggregated version of the Egyptian SAM. In the disaggregated SAM, activities are broken down into ten distinctive accounts; 6 ICT activities and 4 non-ICT. ICT activities are the same as those mentioned in section 1 with the exception of eliminating repairs of computers and communication equipment because of its very negligible impact. Non-ICT activities include primary, manufacturing and processing, social services and other productive and community services.

Commodities are classified into; composite, domestic, imported and exported; with each group of commodities broken down into the above-mentioned 6 ICT and 4 non-ICT commodities. Factors are broken down in the SAM into labor compensation and capital services. Labor compensations are further disaggregated by employer (Government versus non government) and economic sector (ICT versus non ICT). Capital services include both private and public sectors. The economy is composed of three domestic institutions; households, firms and government. Households are represented by a single account. Firms or organized corporations are broken down into ICT and non-ICT companies. Government includes three accounts; one account for general government income and spending in addition to taxes and subsidies accounts. The SAM includes 4 savings accounts for the four institutions which are ICT businesses, non-ICT businesses, government and households. Finally, the SAM includes an account for financial intermediaries,. 3 investment accounts for ICT, Non-ICT and government and two accounts for the rest of the world (both current and capital).

A description of the ICT economy interaction SAM and model can also be found in Khorshid and El-Sadek (2010) and (2011). For the review of the general SAM principles, construction and analysis see Aboul-Einein and Khorshid (2009), Khorshid (2002 and 2008) and Pyatt and Round (1985).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **2007/2008** | Activities  | Commodities | Factors | Institutions | Savings / Investments | ROW | Total | Total |
| Non ICT | ICT | Composite | Domestic | Imports | Exports | Labor | Capital | Households | Business sector | Government |
| Non ICT | ICT | Non ICT | ICT | Non ICT | ICT | Non ICT | ICT | Non ICT | ICT | Government | Indirect taxes | Subsidies | Import taxes | Direct taxes |
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** | **21** | **22** |  |  |
| Activities | Non ICT | **1** |   |   |   |   | 1,044,997.8 |   |   |   | 295,050.0 |   |   |   |   |   |   |   |   |   |   |   |   |   | 1,340,047.8 | 1,383,969.0 |
| ICT | **2** |   |   |   |   |   | 43,171.2 |   |   |   | 750.0 |   |   |   |   |   |   |   |   |   |   |   |   | 43,921.2 |
| Commodities | Composite | Non ICT | **3** | 462,268.2 | 11,970.5 |   |   |   |   |   |   |   |   |   |   | 546,380.0 |   |   | 96,500.0 |   |   |   |   | 187,769.7 |   | 1,309,888.4 | 1,474,298.0 |
| ICT | **4** | 51,363.1 | 2,992.6 |   |   |   |   |   |   |   |   |   |   | 96,420.0 |   |   | 1,000.0 |   |   |   |   | 12,633.9 |   | 164,409.7 |
| Domestic | Non ICT | **5** |   |   | 1,068,503.5 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 1,068,503.5 | 1,114,451.0 |
| ICT | **6** |   |   |   | 45,947.5 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 45,947.5 |
| Imports | Non ICT | **7** |   |   | 241,384.9 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 241,384.9 | 359,847.0 |
| ICT | **8** |   |   |   | 118,462.1 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 118,462.1 |
| Exports | Non ICT | **9** |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 295,050.0 | 295,050.0 | 295,800.0 |
| ICT | **10** |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 750.0 | 750.0 |
| Factors | Labor | **11** | 216,725.7 | 6,474.3 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 9,400.0 | 232,600.0 | 864,774.6 |
| Capital | **12** | 609,690.8 | 22,483.8 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 632,174.5 |
| Institutions | Households | **13** |   |   |   |   |   |   |   |   |   |   | 231,300.0 | 175,974.3 |   | 308,182.1 | 3,759.6 | 6,017.0 |   |   |   |   |   | 61,900.1 | 787,333.1 | 787,333.1 |
| Business sector | Non ICT | **14** |   |   |   |   |   |   |   |   |   |   |   | 430,016.4 | 22,599.2 |   | 9,438.1 | 86,917.4 |   |   |   |   |   |   | 550,071.1 | 550,071.1 |
| ICT | **15** |   |   |   |   |   |   |   |   |   |   |   | 22,483.8 | 100.3 | 12,879.0 |   | 358.4 |   |   |   |   |   |   | 35,821.5 | 35,821.5 |
| Government | Government | **16** |   |   |   |   |   |   |   |   |   |   |   | 3,400.0 | 276.3 | 54,540.8 | 3,474.7 |   | 50,150.7 | -23,868.7 | 13,947.8 | 73,600.0 |   |   | 175,521.6 | 175,521.6 |
| Indirect taxes | **17** |   |   |   |   | 47,374.4 | 2,776.3 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 50,150.7 | 50,150.7 |
| Subsidies | **18** |   |   |   |   | -23,868.7 | 0.0 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | -23,868.7 | -23,868.7 |
| Import taxes | **19** |   |   |   |   |   |   | 13,485.9 | 461.9 |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 13,947.8 | 13,947.8 |
| Direct taxes | **20** |   |   |   |   |   |   |   |   |   |   |   |   | 6,985.2 | 64,664.4 | 1,950.4 |   |   |   |   |   |   |   | 73,600.0 | 73,600.0 |
| Savings / Investment | **21** |   |   |   |   |   |   |   |   |   |   |   |   | 114,072.1 | 96,619.7 | 17,097.4 | -23,970.2 |  |   |   |   |   | -5,015.4 | 200,403.7 | 200,403.7 |
| ROW | **22** |   |   |   |   |   |   | 227,899.0 | 118,000.2 |   |   | 1,300.0 |   |   | 10,585.2 |   | 4,300.2 |   |   |   |   | 0.0 |   | 362,084.6 | 362,084.6 |
| Total |  | 1,340,047.8 | 43,921.2 | 1,309,888.4 | 164,409.7 | 1,068,503.5 | 45,947.5 | 241,384.9 | 118,462.1 | 295,050.0 | 750.0 | 232,600.0 | 632,174.5 | 787,333.1 | 550,071.2 | 35,821.5 | 175,521.6 | 50,150.7 | -23,868.7 | 13,947.8 | 73,600.0 | 200,403.6 | 362,084.7 | ©aelsadek\_2011 |
| Total |  | 1,383,969.0 | 1,474,298.0 | 1,114,451.0 | 359,847.0 | 295,800.0 | 864,774.5 | 787,333.1 | 550,071.2 | 35,821.5 | 175,521.6 | 50,150.7 | -23,868.7 | 13,947.8 | 73,600.0 | 200,403.6 | 362,084.7 |

**Table (3.1): An aggregate version of the ICT economy interaction SAM for Egypt**

**4. Model structure and economic rationale**

The multi-sector ICT economy interaction model of Egypt suggested in this paper follows the computable general equilibrium (CGE) tradition in its dependence on three main components; i) the structure of the economy and its circular flow of income as reflected by the issue-specific base year disaggregated social accounting matrix (SAM) for 2007/08, ii) the independent decisions of the agents intervening in the economy such as producers, consumers, importers and exporters, and iii) the set of closure rules that ensures the consistency of these decisions and reflects the selected policy measures adopted by the Egyptian government (Dervis, De Melo and Robinsonl (1982), Drud, Grais and Pyatt (1986) and Khorshid (1994,1996 and 2003)). The model represents an economy with ten production activities broken down into six ICT related sectors and four non ICT activities. In the ICT sectors, the distinction is made between ICT manufacturing industries (such as computers and electronic components), ICT services (such as telecommunication networking, software publishing, computer programming and data processing) and ICT trade (such as wholesale and retail activities of the ICT products). Non ICT activities consolidates agriculture, fishing and extraction activities in one primary activity. An industrial activity for manufacturing, electricity and gas as well as building and construction. Services sector broken down into social services (such as education and health) and other productive and community services. General Government sector has however a separate account in the model for policy analysis requirements. The model includes four commodity groups ( composite, domestic, imported and exported) with each of them divided into the ten ICT and Non ICT goods and services. Institutional sectors in the model have both current and capital accounts. These include five categories (households, ICT and non ICT companies, general government and the outside world). Investment spending is broken down into ICT, Non ICT and general government gross fixed capital formation. Furthermore, a separate variable representing financial intermediaries is considered to capture capital transfers between institutions. Factors of production is composed of labor compensation and capital services. Labor income is broken down by employer (government, ICT companies and non ICT corporations) and activity (ten production sectors plus general government). Capital services are also broken down by production sectors.

***4.1 Independent Agent decisions***

The behavioral rules of the multi-sector ICT economy interaction model for Egypt can be completely described by the following mechanisms. **First**, to allow for testing alternative growth prospects of the ICT sectors and their impact on the rest of the economy, gross output in these sectors is exogenously determined whereas the output of non-ICT sectors is determined by the interaction between the market supply and demand forces. In the ICT sectors, labor demand and intermediate inputs are computed using a Leontief fixed coefficients production function. Because output in these sectors is exogenously specified, the gross operating surplus (capital services) is computed as a residual. **Second**, In the non-ICT sector a two-level (or nested ) production function is adopted. The first level divides gross output between value added and intermediate inputs using a Leontief fixed coefficient production function whereas the second level allocates the value added between labor and capital services using a constant elasticity of substitution (CES) function. **Third**, In the ICT sectors, given exogenous output and endogenous domestic demand for ICT products, exports are computed as a residual. Domestic demand for ICT products is the sum of intermediate demand (estimated from the Leontief production function), household final consumption (aggregate consumption is computed as a fixed share of household’s nominal income and the allocation of spending by commodity type is determined by a linear expenditure system (LES)), exogenous government final spending and investment expenditure (computed as a fixed quantity share). **Fourth**, in non ICT sectors, imports, exports and the production for domestic use (or domestic sales) are determined simultaneously using both a constant elasticity of substitution (CES) and a constant elasticity of transformation (CET) functions. Composite demand for non ICT commodities is determined by the sum of final consumption, intermediate demand and investment spending. The Demand for composite non ICT is then broken down into domestically produced and imported goods using a cost minimization function subjected to a CES constraint. Similarly, gross output of these sectors are sold to domestic and foreign markets using profit maximization subjected to a CET function. The results of this process are imports, exports and production for domestic use in the non ICT sectors. **Fifth**, imports are treated as an imperfect substitutes of domestic products using Armington elasticity of substitution based on a Cost minimization function subjected to a CES constraint. According to this formulation, the substitution between domestic and imported commodities depends on the prices of domestic and imported goods and the elasticity of substitution. **Sixth**, with respect to the market of factors, the model can be viewed as a fixed wage rate one with exogenous government and non government demand for ICT labor. In this formulation, the quantity of labor demand in government sector depends on public sector employment policy, demand for labor in the private ICT and non ICT sectors is determined using a Leontief and CES functions, respectively. Given fixed ICT labor quantity, the demand for labor in non ICT sectors is determined. **Seventh**, the distribution and redistribution of national income is determined in the model as follows: The national wage bill is entirely allocated to households sector. Operating surplus of the two production activities is distributed on domestic institutions and the outside world based on the pattern of ownership of the productive assets. Households, ICT companies and non ICT corporations are assumed to allocate their total receipts on different outlays as a fixed share of nominal income. After netting current transfers between institutions, they are left with their disposable income that is allocated between final consumption and gross savings. Government transfers to domestic and foreign institutions are fixed in nominal term. Public final consumption – including government wage bill and purchases of commodities – is however fixed in real term. Households aggregate private consumption is estimated as a function of their income that, in turn, depends on wage income, operating surplus of unincorporated business as well as other transfers. **Eights**, the model includes a complex module of prices and deflators. The price of unit value added is determined as a function of the rate of return on capital and the average wage rate of the sector. Price of composite goods is estimated using prices of domestic and imported commodities. Given prices of composite goods and unit value added, output price of commodities are determined. This price is evaluated at cost of production . When we add to it taxes and subtract subsidies, we obtained producer price of output.. Similarly, landed prices of imports is determined as the sum of world price in local currency plus import duties.

***4.2 Markets Clearing Mechanisms***

The market clearing mechanisms of the model include the following: (1) the labor markets consist of government and non government labor, each divided into workers of ICT and non ICT sectors. In these markets all prices are exogenous, and demand for non ICT labor clears the market. Markets for capital services are only modeled for the non ICT sector. Given exogenous ICT production, capital income in this sector is computed as a residual after excluding other inputs, (2) in the product markets, production of non ICT sector is determined using a flexible price clearing mechanisms and ICT production is supply determined. In ICT sector, supply is fixed and exports clear the market. (3) on the macroeconomic level, the model is investment driven. Investment spending is exogenous, households and companies savings are determined as a fixed share of their nominal income and government savings are estimated as the difference between income and current spending. The difference between domestic savings and investments is channeled to the outside world in the form of net capital outflows.

***4.3 Model Calibration and Estimation***

The model calibration relies mainly on the base year social accounting matrix of Egypt and collected socioeconomic indicators produced by the ministry of economic development (MOED), the central bank of Egypt (CBE), the ministry of finance (MOF) and the central agency of public mobilization and statistics (CAPMAS). Most structural parameters of the model such as the input output coefficients, tax and subsidy rates, saving rates, share parameters of the production functions are computed directly from the SAM. The behavior parameters of the model - such as the elasticity of substitution between domestic and imported goods and the elasticity of transformation between domestic sales and exports - are estimated from collected time series data, results of similar studies on Egypt and initial runs of the model. With respect to the output results of the model, the recorded indicators are grouped under a set of tables including GDP sources, GDP uses and current account of the balance of payments.

**5. Policy Formulation and Experimental Analysis**

***5.1 Policy formulation***

In this section the model is used to conduct policy experiments directed to (i) assess the impact of the ICT sector on the economy wide performance of Egypt and (ii) determine the effects of adopting an appropriate development strategy that allows Egypt to be an information-based economy as an important step in its road towards the knowledge society.

Against this background, we assume that Egypt will pursue a comprehensive strategy which relies on extensive utilization of information and communication technology in all sectors of the economy supported by an enhanced ICT sector and an export oriented ICT production. In order to implement this ambitious ICT strategy, the government of Egypt is going to adopt the following policy measures:

1. Increase the growth rates of gross fixed capital formation with special emphasis on ICT investment spending.
2. Adopt appropriate measures to increase the output, value added and factors income of the ICT activity.
3. Implement a national training, reorientation and capacity building program leading to an enhanced factor productivity and labor efficiency in the economy as a whole based on advanced ICT.
4. Apply a foreign exchange policy to promote ICT exports to the outside world.

In this respect, the model is mainly used to capture, and make the distinction between, two ICT economy wide effects: (i) the impact of increasing investments, ICT output, labor compensations and demand for ICT commodities on the macroeconomic performance measured by the principal aggregates of national accounts ( This will be nominated in this paper as the "**direct effects**" ) and (ii) the effects generated by ICT spreading out on the efficiency of labor factor and total factor productivity. These type of effects will be considered as an "**indirect effects**". These comprehensive strategic trends are implemented and tested using a comparative static approach by assuming that these policy measures will be implemented over a period from 5 to 8 years whereas the impact is assumed to continue for a longer period. Based on this economic rationale, gross capital formation will increase by 30 percent in real term in the ICT sectors and 20 percent in the non ICT sectors. This total investment growth is equally distributed over five years period. ICT production - in this ICT-based development strategy - is expected to grow by 25 percent, and ICT labor demand in both government and private sectors would increase by 20 percent during the planning period. The adopted strategy would result also in a similar increase in non-ICT total factor productivity by 8 percent and non-ICT labor efficiency by 10 percent over the whole planning period. The assumptions reflecting the comprehensive ICT strategy is based on previous analytical studies, the analysis of the economic dimensions of the ICT sector done by the authors, ICT expert opinions and the discussion with several economists.

***5.2 Experimental analysis***

Based on the above rationale, the analysis of the Egyptian economy based on the developed ICT economy interaction model was carried out on ***three levels***; the ***first level*** generates the direct economy wide effects (generated by the increase of production and investments) , the ***second one*** isolates the indirect effects ( based on the enhanced labor and total factor productivity) and finally the ***third level*** computes the overall integrated impact of both the direct and indirect effects of the ICT strategy. The obtained results are grouped under four tables as follows:

1. The first table concentrates on capturing the impact on sources of gross domestic product (GDP) in real term on an aggregate level. It estimates the impact on ICT and non ICT sectors as well as the general government GDP. Furthermore, the table computes net indirect tax income with the objectives of differentiating between GDP at factor cost and GDP at market price in real term.
2. The second table provides a more disaggregated view of the impact on GDP growth. In this table, non ICT sector include the GDP of four production activities and the general government. ICT is also divided into government and non government sectors.
3. The third table identifies the impact on the uses of GDP in real term. It measures the performance of final consumption spending, gross investment and net exports under the assumptions of the ICT strategies.
4. Table four investigates the effects on Egypt's external balance resulting from the ICT strategy. It includes the current accounts of the balance of payment such as exports, imports, trade balance and the current account surplus (or Deficit).

***5.3 Impact on sources of Real GDP***

Based on table (5.1), ICT value added in the base year accounts for 3.2 percent whereas the non ICT sector represents 83.8 percent of aggregate GDP. The government GDP does not exceed 9 percent of GDP. This GDP structure reflects the limited share of ICT sector in the economy and then the need to enhance its capacity if the ICT-based development strategy is to be implemented. The table reveals a number of analytical points:

**First**, the ICT sector benefits mainly from the direct effect of increasing its production by 25 percent. The economy wide impact on the non ICT sector becomes apparent only via the indirect longer term effects of labor efficiency and total factor productivity. The direct and indirect effects of the ICT strategy on non ICT GDP are then 1.3 and 2.2 percent respectively, and the overall long term growth rate represents then 3.4 percent. Since the policy experiment assumes no increase in government final spending, the impact on government GDP is negligible.

**Second**, the overall growth of GDP at factor cost due to the adoption of a new ICT strategy is around 3.8 percent. When the impact of net indirect taxes is considered,

**Table (5.1) Impact of ICT Development Strategy on Sources of GDP**

**(Aggregate Accounts – Real term – LE Million)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Economic Indicators** | **Base Year** | **Direct Effect** | **Indirect Effect** | **Total Impact** |
| **Value** | **(%) of GDP** | **Value** | **Growth (%)** | **Value** | **Growth (%)** | **Value** | **Growth (%)** |
| **ICT Sector****Non – ICT Sector****Government Sector** | **29,457.9****750,116.3****75,800.0** | **3.2****83.8****8.5** | **36,797.4****759,510.5****75,720.0** | **24.9****1.3****-0.1** | **29,457.9****766803.3****75,800** | **0.0****2.2****0.0** | **36,797.4****775,730.6****75,720.0** | **24.9****3.4****-0.1** |
| **GDP Factor Sector** | **855,374.2** | **95.5** | **872,027.9** | **1.9** | **872,061.2** | **2.0** | **888,248.0** | **3.8** |
| **Net indirect tax** | **40,229.7** | **4.5** | **42,888.0** | **6.6** | **41,799.4** | **3.9** | **44,303.0** | **10.1** |
| **GDP at Market Price** | **895,599.2** | **100** | **913,596.8** | **2.0** | **1,015,530.0** | **13.4** | **1,036,530.4** | **15.7** |

**Table ( 5.2) Impact of ICT Development Strategy on Sources of GDP**

**(ICT / Non – ICT Sectors – Real term – LE Million)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Economic Indicators** | **Base Year** | **Direct Effect** | **Indirect Effect** | **Total Impact** |
| **Value** | **(%) of GDP** | **Value** | **Growth (%)** | **Value** | **Growth (%)** | **Value** | **Growth (%)** |
| **ICT sector****ICT non – government****ICT government** | **28,957.9****500.0** | **3.4****0.1** | **36,197.4****600.0** | **25.0****20.0** | **28,957.9****500.0** | **0.0****0.0** | **36,197.4****600.0** | **25.0****20.0** |
| **Non-ICT sector****Primary Activities****Manufacturing****Productive Services****Social Services****Non – ICT government** | **750,116.3****244,777.5****188,616.8****248,569.2****68,152.8****75,800** | **87.8****28.6****22.1****29.1****7.9****8.8** | **759,510.5****246566.0****192811.2****249697.2****70436.1****75720.0** | **1.3****0.7****2.2****0.5****3.3****0.1** | **766,803.3****246,783.7****197,080.4****249,890.7****73,048.5****75,800** | **2.2****0.8****4.5****0.5****7.2****0.0** | **775,730.6****248,443.2****201,075.9****250,906.3****75,305.2****75,720.0** | **3.4****1.5****6.6****0.9****10.5****-0.1** |
| **GDP at Factor Cost** | **855,374.2** | **100.0** | **872,027.9** | **1.9** | **872,061.2** | **2.0** | **888,248.0** | **3.8** |

GDP at market price grows by more than 4 percent over the planning period. It is worth noting that the increase in total factor productivity would enhance the production of non ICT, the demand for commodities, factors income as well as the income of domestic institutions which would lead to a 10.1 percent increase in net indirect taxes.

**Third**, it can be concluded that the longer term indirect effects of increasing productivity of factors represents the most important determinant of any suggested ICT strategy with respect to its impact on the rest of the economy.

**Fourth**, When the GDP is disaggregated by economic sector, the figures in table(5.2) reflect the following points:

1. Given the capital intensive nature of most extraction activities and the difficulty to implement advanced ICT in the Egyptian agricultural and fishing sector, the primary activity sectors grow moderately by 1.5 percent over the projection period.
2. Social services including education and health activities come on top of the list with respect to the magnitude of the impact of the suggested ICT strategy. The direct effect of increasing ICT production and investment increases social services sector GDP by 3.3 percent and the indirect efficiency effect augments its GDP by 7.2 percent. The overall impact of the ICT strategy on social services GDP exceeds 10 percent in the long run.
3. Manufacturing and other industries also witness a considerable improvement in their GDP growth with an average of 2.2 percent under the ICT direct effect and 4.5 percent due to factor productivity growth, which results in a total impact on their GDP that reaches 6.6 percent over the projection period.
4. The consolidated impact of ICT strategic changes on non ICT government services and other services is negligible. This result applies equally to both the direct and indirect effects.

***5.4 Demand for Goods and Services***

Sources of GDP growth can be similarly evaluated by observing the impact on its uses which include final consumption spending , investment expenditures and net foreign demand for goods and services (exports less imports). Given exogenous government final consumption and investment spending in the model, the impact is mainly captured by the improved performance of exports and private final spending. As table (5.3) shows, the adopted ICT enhanced strategy has contributed to a significant growth of these economic indicators. The expected overall growth in real term of these two economic aggregates reaches 11.5 and 12.6 percent, respectively. Based on this results, It can be concluded that the ICT strategy will affect both the domestic and foreign demand for commodities. Since the increase in gross output of ICT and non ICT sectors exceeds the growth in domestic demand, the additional or excess production is channeled to the outside world in the form of exports. Note here again that the indirect effect of ICT strategy is significantly higher than its direct impact. As the results of table (5.3) show, total exports in real term drop by 2.6 percent when the direct effect is isolated or separately estimated. This can be explained by the fact that the magnitude of the direct impact - resulting from an augmented investment spending and increased production of the ICT sector – succeeds to enhance the domestic demand which absorbs part of the domestic production directed to exports. On the other, the improved growth environment resulting from the new ICT strategy would similarly increase the demand for imported commodities by around 4.3 percent. When the enhanced performance of private consumption and exports is matched with the increase in imports, the total impact on GDP at market price (in real term) grow only by 4.1 percent over the period of analysis. Since government consumption is fixed in real term (based on the closure rules of the model), public consumption spending is practically not affected by the suggested ICT strategy.

***5.5 External Balance***

The experimental analysis reflects a clear improvement in the balance of the Egyptian economy with the outside world as a result of applying the ICT new strategy. In table (5.4), the ICT exports grow by 44.6 percent as a result of the ICT new development policy. This considerable improvement results from the assumed exogenous increase of the production of the sector coupled with the ICT export promotion policy within the framework of the adopted ICT development strategy. Non ICT exports also witness 10 percent overall growth rate under the ICT new strategy.

This result is explained on the one hand by the favorable growth prospects of the economy, and described on the other hand by the increase in labor efficiency and total factor productivity of the non ICT production sector. It should be noted here, that the improved performance of ICT exports results mainly from the “direct effect” of investment and ICT production growth. The increase in non ICT exports is however the outcome of the “indirect effect” of enhancing total factor productivity. The accumulated impact of the ICT strategy on the growth rate of total exports becomes then 11.5 percent. Because imports increase only by 4.7%, the balance of trade of goods and services is expected to witness an improvement. The results of the multi-sector ICT economy interaction model show that the balance of trade (exports less imports) improves from LE – 50,099 million in the base run to only LE – 35.7 million under the ICT new strategy. Similarly, the current account deficit of the balance of payments has decreased from LE 5,015 Million in the base year to only LE 438 Million when the new ICT strategy is adopted.

**Table (5.3) Impact of ICT Development Strategy on Uses of GDP**

**(Real term – LE Million)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Economic Indicators** | **Base Year** | **Direct Effect** | **Indirect Effect** | **Total Impact** |
| **Value** | **(%) of GDP** | **Value** | **Growth (%)** | **Value** | **Growth (%)** | **Value** | **Growth (%)** |
| **Private Consumption****Public Consumption** | 647,799.897,498.3 | 72.39.9 | 660,477.597,498.3 | 2.00.0 | 717,275.797,498.3 | 10.70.0 | 729,504.397,498.3 | 12.60.0 |
| **Total Consumption** | 745,298.1 | 83.2 | 757,975.8 | 1.7 | 814,774.0 | 9.3 | 827,002.6 | 11.0 |
| **ICT Investment****Non – ICT Investment****Government Investment****Total investment** | 12,632.6153,869.633,897.8200,400.0 | 1.417.23.822.4 | 16,422.3184,643.540,677.4241,743.2 | 30.020.020.020.6 | 12,632.6153,869.633,897.8200,400.0 | 0.00.00.00.0 | 16,422.3184,634.540,677.4241,743.2 | 30.020.020.020.6 |
| **Exports (FOB)**  | 295,800.2 | 33.0 | 288,252.6 | -2.6 | 337,452.2 | 14.1 | 329,824.4 | 11.5 |
| **(Less) Imports (CIF)**  | 345,899.0 | -38.6 | 374,374.9 | 8.2 | 337,096.1 | -2.5 | 362,039.9 | 4.7 |
| **GDP at market Price**  | 895,599.2 | 100 | 913,596.8 | 2.0 | 1,015,530.0 | 13.4 | 1,036,530 | 15.7 |

**Table (5.4 ) Impact of ICT Development Strategy on the Current account of the Balance of Payment**

**(Normal Term – LE Million)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Economic Indicators** | **Base Year** | **Direct Effect** | **Indirect Effect** | **Total Impact** |
| **Value** | **(%) of GDP** | **Value** | **Growth (%)** | **Value** | **Growth (%)** | **Value** | **Growth (%)** |
| **ICT Exports****Non – ICT Exports** | **4,125.0****291,675.2** | **0.5****32.5** | **6,028.3****282,224.4** | **46.1****-3.2** | **4,059.6****33,392.6** | **-1.6****14.3** | **5,963.4****323,860.9** | **44.6****11.0** |
| **Total Exports** | **295,800.2** | **33.0** | **288,252.6** | **-2.6** | **337,452.2** | **14.1** | **329,824.4** | **11.5** |
| **ICT Imports****Non – ICT Exports**  | **121,375.0****224,524.1** | **-13.5****-25.1** | **126,768.0****247,606.9** | **4.4****10.3** | **123,551.5****213,544.6** | **1.8****-4.9** | **128,404.9****233,635.0** | **5.8****4.1** |
| **Total Imports**  | **345,899.0** | **-38.6** | **374,374.9** | **8.2** | **337,096.1** | **-2.5** | **362,039.9** | **4.7** |
| **Trade Balance**  | **-50,098.9** | **-5.6** | **-86,122.3** | **71.9** | **356.1** | **-100.7** | **-32,215.5** | **-35.7** |
| **Current Account Surplus (deficit)**  | **-5,015.4** | **-0.6** | **25,462.5** | **-607.7** | **-26,890.9** | **438.0** | **-342.1** | **-93.2** |

**Summary and Conclusion**

This paper is mainly directed to investigate and quantitatively analyze the important issue of the economy wide impact of adopting an **integrated strategy** to enhance the information and communication technology (ICT) as a catalyst for moving Egypt towards a **knowledge economy** and a **modern society**. The appropriate approach to achieve this objective is to develop a comprehensive analytical database coupled with a consistent accounting framework and to construct an efficient economy wide model especially designed to assess the impact of ICT on the rest of the economy. A **first step** in this respect was to define the scope and components of the ICT sector and to determine its interactions with the other parts of the economy. The **second step** concentrated on determining the most appropriate methods to estimate the ICT related economic indicators in consistency with the norms and rules of the internationally recognized revised system of national accounts (SNA). Having finalized these two primary steps, we have proceeded to assemble a multi-sector ICT economy interaction accounting framework that can be used to capture the complex linkages and flow of income between this technology advanced sector and the rest of the economy.

This accounting framework consists of an **ICT- oriented social accounting matrix** (SAM) for the Egyptian economy (Khorshid and El Sadek 2010). The estimated SAM can be viewed as a consistent and comprehensive analytical database for building various models to address the economy wide impact of the ICT sector. The SAM used to calibrate the model relied on various socioeconomic indicators produced by the ministry of economic development (MOED), the central agency for public mobilization and statistics (CAPMAS), the ministry of finance (MOF) and the central bank of Egypt (CBE) . The **multi-sector ICT interaction model** follows the computable general equilibrium (CGE) tradition with an emphasis on the ICT sector and its interactions with other production sectors, domestic institution and the outside world. It can be viewed as an **issue oriented extended economy wide model** used primarily to trace the impact of alternative policy measures and future strategies related to the ICT sector. The model represents an economy with ten production sectors (including six ICT activities and four non ICT activities) , four commodity groups (composite, domestic, imported and exported) with each divided into ten sectors for ICT and Non ICT goods and services, four domestic institutions(including households, ICT and non ICT companies, the general government) and the outside world. The investment-saving accounts are broken down by institution and activity type. Factors of production is composed of labor compensation and capital services, with the labor account broken down by employer (government versus non government) and activity (ten ICT and non ICT sectors), and the capital account divided by activity type.

The model is mainly used to conduct policy experiments directed to assess the impact of the ICT sector on the economy wide performance of Egypt with the objectives of developing an appropriate ICT strategy that allows Egypt to be an information-based economy and a knowledge-based society. More specifically, the model is used to capture, and make the distinction between, two ICT economy wide effects: (i) the impact of increasing investments, ICT output, labor compensations and demand for ICT commodities on the macroeconomic performance measured by the principal aggregates of national accounts, which is nominated in this paper as the "***direct effects***" and (ii) the effects generated by ICT spreading out on the efficiency of labor factor and total factor productivity. This type of effect will be considered as an "***indirect effects***". Against this background, the government of Egypt is assumed implement an ambitious ICT strategy composed of **four policy packages** which are: (i) to Increase the growth rates of gross fixed capital formation with special emphasis on purchasing ICT investment commodities, (ii) to adopt various measures to increase the output, value added and factors income of the ICT activity, (iii) to implement a national training, reorientation and capacity building program leading to an enhanced factor productivity and labor efficiency in the economy as a whole based on advanced and up to date ICT, and (iv) to apply an ICT export promotion policy.

The results of applying the ICT economy interaction model to assess the impact of the adopted ICT development strategy revealed a number of analytical points.

**First**, the ICT sector benefits mainly from the direct effect of increasing its production and investment spending whereas the impact on non ICT sector becomes apparent only via the indirect longer effects of enhancing labor efficiency and total factor productivity. **Second**, The analytical results show that the longer term indirect effect of increasing productivity of factors represents the most important determinant of the impact of any suggested ICT strategy on the growth prospects of the economy. **Third**, the adoption of the ICT strategy will affect both the domestic and foreign demand for commodities. Since the increase in gross output of ICT and non ICT sectors exceeds the growth in domestic demand, excess production is channeled to the outside world in the form of exports. **Fourth**, the experimental analysis shows a clear improvement in the balance of the Egyptian economy with the outside world as a result of applying the ICT new strategy . This improvement is more apparent in exports, trade balance and the current account surplus. **Fifth**, the savings of households, ICT companies and non ICT corporations increase, and government current deficit is expected to decrease over time from when the ICT enhanced scenario is adopted. **Sixth**, The enhanced growth environment of the economy would slightly increase government capital income (profit transferred from public enterprises). transfers from other non government domestic institutions but it considerably improve tax income.

Although the disaggregated static ICT economy interaction model has provided several fruitful **analytical** results that can be used to support the decision making process with respect to the formulation of an efficient and effective ICT economic strategy, the analysis can be improved by extending the static ICT economy interaction model to a fully dynamic one

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