International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

L.1451
(11/2019)

SERIES L: ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

Methodology for assessing the aggregated positive sector-level impacts of ICT in other sectors

Recommendation ITU-T L.1451

ITU-T L-SERIES RECOMMENDATIONS

ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

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Recommendation ITU-T L.1451

Methodology for assessing the aggregated positive sector-level impacts of ICT in other sectors

Summary

To date no international comprehensive methodology exists to assess the environmental impact of information and communication technology (ICT) at sector level, or to assess the aggregated positive effects of the ICT sector on other sectors of the economy.

Without a standard methodology evaluating the positive impacts of ICT, the role of ICTs in the fight against global warming will be only partially perceived.

Recommendation ITU-T L.1451 addresses the need to contribute to achieve the targets and goals of the 2030 Agenda for Sustainable Development, especially its Sustainable Development Goal 13 (SDG13), the Connect 2030 Agenda and the Paris Agreement from a global perspective.

This Recommendation addresses the opportunity to use a computable general equilibrium (CGE) model as a possible methodology for simultaneously assessing the environmental and economic impacts of ICTs at the sectoral level.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T L.1451	2019-11-13	5	11.1002/1000/14083

Keywords

Aggregated positive impacts of ICT, computable general equilibrium (CGE) model, greenhouse gas (GHG), input-output tables, second order effects

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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Introduction

Use of information and communication technologies (ICTs) results in environmental loads, such as energy consumption, greenhouse gas (GHG) emissions and e-waste, which are also called first order effects of ICTs. However, ICTs also have energy saving and emission reduction potential, such as dematerialization, movement reduction or increased productivity in many industry sectors, which are called second order effects. The energy consumption and GHG emissions caused by ICTs have been studied in depth and several papers have investigated the energy savings and emission reduction potential of ICT solutions in other sectors. These calculations are based on a direct link between a certain level of activities and ICT or ICT solutions. However, ICT has a considerably wider impact on industrial activities and human behaviour, when estimating the impacts at sector level, such as rebound effects.

For example, use of ICT in industry can help to realize efficiencies in production and logistics, reducing investment in raw materials and energy per unit of production, but also may cause increased production due to increased efficiency or increased demand due to a reduction in product prices. It can also lead to surplus management resources in the enterprise, which can then be reallocated to create new business markets. Also, at a personal individual level, users can save time or money, when they use some ICT services such as teleworking and online shopping, but this may have some additional impact, e.g., a leisurely drive and economic activities. These extended impacts may also cause greenhouse gas (GHG) emissions. Furthermore, ICT allows the outsourcing of manufacturing, which has created millions of jobs especially in less developed areas. In addition, thanks to the availability of detailed information online, connectivity, the relative safety of communications and the ease of navigation, people who previously would not have been keen on travelling are now more likely to do so.

While it is difficult to directly allocate such activities with an increase of GHG emissions caused by ICT, the correlation of the penetration increases of the Internet with the per-capita increase of GHG emissions shown in Figure 0 suggests a strong indirect impact from the ICT sector. This indicates that limits and counter effects should be taken into account.

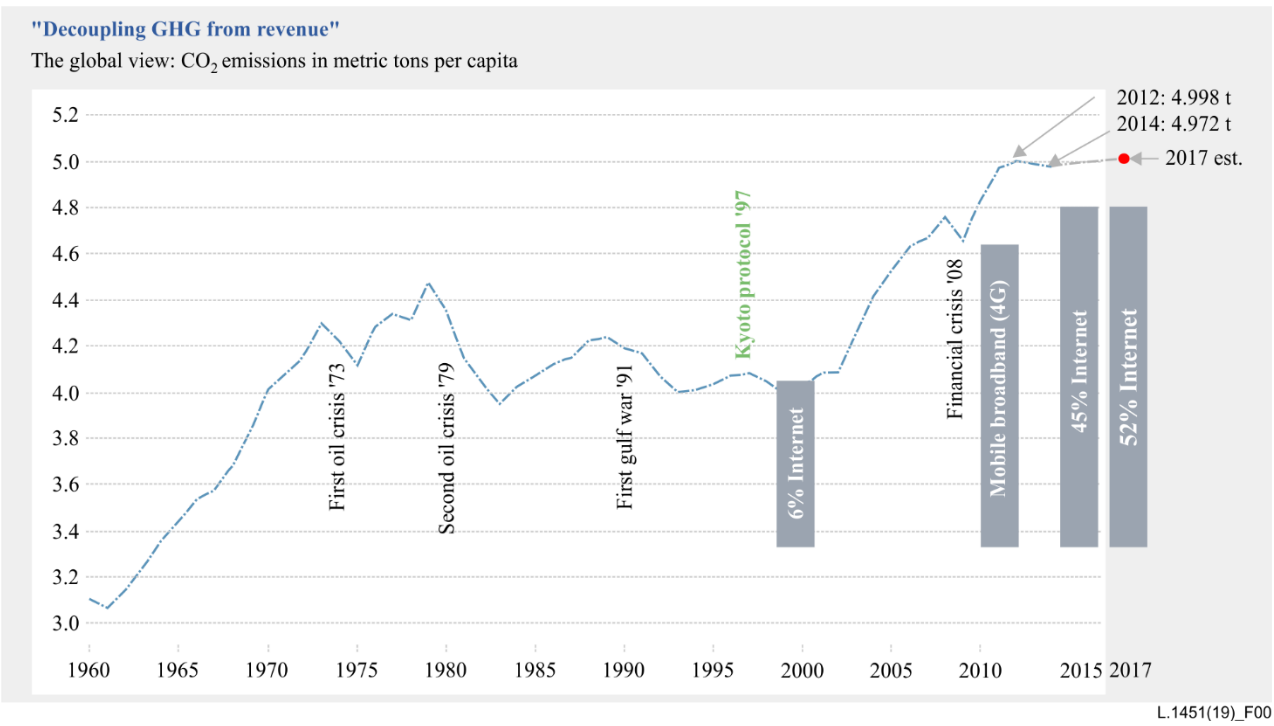

Figure 0 – GHG per-capita development (blue line) and Internet penetration (grey bars)

Needless to say, ICTs have brought huge positive impacts on economic activities. Use of ICTs in manufacturing have improved efficiency in production activities and required labour and time in production have been reduced. ICTs create a lot of new jobs for people and make human life more convenient.

ICT can contribute to both economic growth and environmental load reduction. Therefore, it is desirable to assess the positive economic impacts of using ICT, as well as the environmental impacts. This Recommendation defines a methodology for assessing the aggregated positive sector-level impacts of ICT in other sectors using a computable general equilibrium (CGE) model, which takes an economic approach that can also consider a wider impact based on economic equilibrium.

Recommendation ITU-T L.1451

Methodology for assessing the aggregated positive sector-level impacts of ICT in other sectors

1 Scope

This Recommendation uses a computable general equilibrium (CGE) model as a possible methodology for simultaneously assessing the environmental and economic impacts of information and communication technologies (ICTs) at the sectoral level.

The CGE model adopts a top-down economic approach using economic input-output tables. Compared to a bottom-up assessment method, it provides a model of the overall environmental impacts at the sectoral level without collecting complex sets of data. Since it uses a macroeconomic approach, the proposed method makes an attempt to capture the economy-wide rebound effects in addition to the primary and secondary effects of ICTs.

As a principle, the CGE model calculates the pricing effects of using ICT services and derives the positive effects of this ICT usage. However, the introduction of ICT services leads to effects which are not directly measurable in terms of costs considering the externalities of environmental effects in the price mechanism. These effects (not measurable in terms of costs) are not evaluated in this version of the Recommendation.

This Recommendation defines an evaluation procedure to be applied when assessing the positive impacts of ICT including (but not limited to) the definition of conditions, the data collection process and reporting obligations.

At this stage, this method aims to assess the positive impacts of ICT at the sectoral level and would need to be adapted to be applied at the organizational level.

This Recommendation also aims to promote the use of a CGE model when evaluating the positive impacts of ICT services and encourages interested organizations to contribute to improve this Recommendation.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T L.1400] Recommendation ITU-T L.1400 (2011), *Overview and general principles of methodologies for assessing the environmental impact of information and communication technologies*.

[ITU-T L.1410] Recommendation ITU-T L.1410 (2014), *Methodology for environmental life cycle assessments of information and communication technology goods, networks and services*.

[ITU-T L.1450] Recommendation ITU-T L.1450 (2018), *Methodologies for the assessment of the environmental impact of the information and communication technology sector*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 emission factor [b-GHG Protocol CS]: A factor allowing GHG emissions to be estimated from a unit of available activity data (e.g., tonnes of fuel consumed, tonnes of product produced) and absolute GHG emissions.

3.1.2 first order effects [ITU-T L.1410]: The impact created by the physical existence of ICTs and the processes involved, e.g., GHG emissions, e-waste, use of hazardous substances and use of scarce, non-renewable resources.

3.1.3 greenhouse gases (GHGs) [b-GHG Protocol CS]: For the purposes of this methodology, GHGs are the seven gases listed in the Kyoto Protocol:

– carbon dioxide (CO_2)
– methane (CH_4)
– nitrous oxide (N_2O)
– hydrofluorocarbons (HFCs)
– perfluorocarbons (PFCs)
– sulphur hexafluoride (SF_6)
– nitrogen trifluoride (NF_3).

3.1.4 ICT service [ITU-T L.1400]: This covers the combination of ICT goods and ICT networks. An ICT service is produced in one or more nodes of the network and provided to users or other ICT systems over the ICT network.

3.1.5 input-output tables [b-OECD]: Tables that describe the sale and purchase relationships between producers and consumers within an economy.

3.1.6 non-ICT sector: The sector(s) including industries that do not belong to the ICT sector.

3.1.7 second order effects [ITU-T L.1410]: The impact and opportunities created by the use and application of ICTs. This includes environmental load reduction effects which can be either actual or potential.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 advanced CGE model: A computable general equilibrium (CGE) model for calculating greenhouse gas (GHG) emissions and gross domestic product (GDP) for an ICT use case, which can take into account the effects caused by ICT.

3.2.2 basic CGE model: A computable general equilibrium (CGE) model for calculating greenhouse gas (GHG) emissions and gross domestic product (GDP) in a reference case.

NOTE – In the context of this Recommendation, the terms "advanced CGE model" and "basic CGE model" apply to the positive effects of ICT services only. However, scientific literature demonstrates that CGE models can be used for other purposes.

3.2.3 economic equilibrium: A situation in which economic forces such as supply and demand are balanced.

3.2.4 economy-wide rebound effect: The additional impacts caused by additional activities occurring due to time gains and additional activities occurring due to surplus management resource gains.

3.2.5 ICT sector: The ICT sector includes industrial companies producing goods or services that must primarily be intended to fulfil or enable the function of information processing and communication by electronic means, including transmission and display.

NOTE – This is based on [b-ISIC].

3.2.6 ICT use case: A case that describes the specific use of one or more ICT services in society.

3.2.7 reference case: A case that describes a situation where assumed ICT services are not used in society.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AIM/CGE Asia-Pacific Integrated Model / Computable General Equilibrium

BAU Business As Usual

BEMS Building Energy Management System

CGE Computable General Equilibrium

CO_2 Carbon dioxide

CO_2e CO_2 equivalent

FEMS Factory Energy Management System

GDP Gross Domestic Product

GHG Greenhouse Gas

HEMS Home Energy Management System

ICT Information and Communication Technology

IPCC AR5 Intergovernmental Panel on Climate Change 5th Assessment Report

ITS Intelligent Transport System

LCA Life Cycle Assessment

RAS Ratio Allocation System

SAM Social Accounting Matrix

SCM Supply Chain Management

5 Conventions

None.

6 General principles

The use of information and communication technologies (ICTs) results in an environmental load, which is also called the first order effects of ICTs. However, ICTs also have positive effects, such as, energy saving and emission reduction potential, which are also called second order effects. In addition, ICT has a considerably wider impact on industrial activities and human behaviour, including global development (the so-called rebound effects). [ITU-T L.1450] defines how to calculate the ICT sector footprint covering only first order effects. This Recommendation is mainly intended to specify how to assess second order effects, as well as considering rebound effects.

This Recommendation defines a specific method for assessing the environmental and economic impacts of information and communication technology (ICT) use at the sector level with a CGE model. The method uses an economic top-down approach on the basis of economic input-output tables. Compared with an evaluation method using a bottom-up approach, this method makes it easier to understand the overall environmental impacts at the sector level without collecting complex data. Since it uses a CGE model based on economic theory that also considers economic equilibrium, the method seeks to take into account some economy-wide rebound effects in addition to first and second order effects of ICT use.

Economy-wide rebound effects defined in this Recommendation include additional impacts caused by additional activities incurred in the time gained by an end user using an ICT service and additional activities caused by the surplus management resource gained by an enterprise using ICT services. For example, for an individual person, some ICT services such as teleworking can save time gained by an end user using an ICT service, which then may cause additional impacts e.g., a leisurely drive and economic activities. Furthermore, use of ICT in industry can help to realize efficiency improvements in production and logistics, reduction of investment in raw materials and energy per unit of production and increased production due to increased efficiency or increased demand due to a reduction in product prices. It can also lead to surplus management resources in the enterprise, which can then be used to create new business markets.

To increase transparency of the assessment using the proposed method, the assumptions and sources of data used shall be clearly documented.

7 Evaluation procedure

Implementation of a CGE model for estimating the environmental and economic impacts of ICT use shall be based on the following steps shown in Figure 7-1. Note that details regarding the different steps are given in clauses 8 to 12.

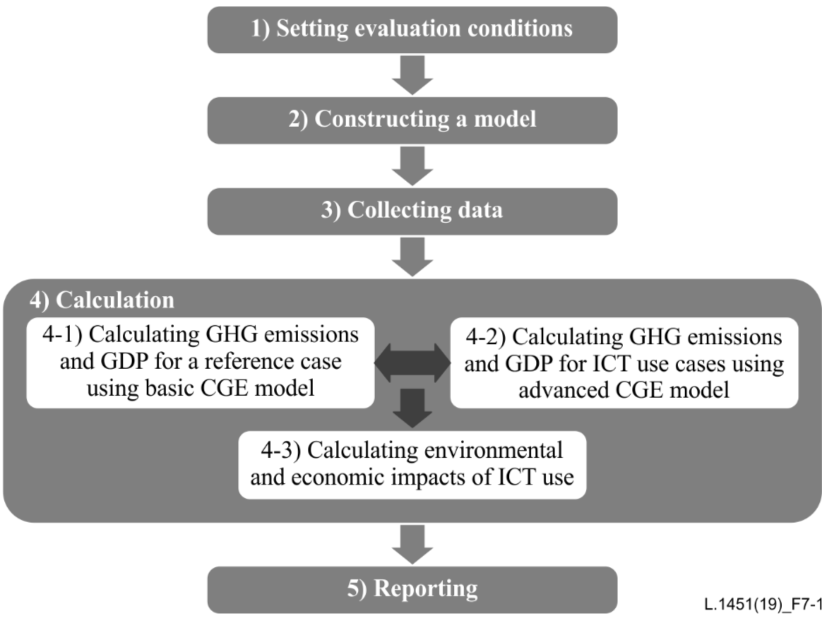

Figure 7-1 – Evaluation procedure

1) Setting evaluation conditions (see clause 8)

This includes:

– the definitions of various preconditions for evaluation, including a time period for evaluation and a baseline for comparison (ordinarily one year),
– the scope of evaluation,
– the ICT services considered for evaluation and

– the kinds of effects being evaluated (e.g., first order effects, second order effects, rebound effects, or others).

It should be noted that the scope of the study may cover either a geographical area (city, region, country, etc.), a specific industrial domain (in the case where the study concerns the positive impacts of ICT services in the aeronautics industry for example) or a combination of both (positive impact of ICT services for tourism in France for example).

2) Constructing a model (see clause 9)

This part is related to the definition of the CGE model to evaluate the environmental and economic impacts generated by the use of ICT services.

3) Collecting data (see clause 10)

This part defines the collection process of the data to be used. Two sets of data are needed for the evaluation.

A) Basic input data for the CGE model:

- Input-output tables: basically, input-output tables [b-OECD] for the geographical area or the industry segment being evaluated.
- Emission factors: GHG emission factors sorted by energy type.
- Other input data that could be deemed as necessary as described in [b-NIES].

B) Data related to ICT use:

- ICT penetration rates: Penetration rates of the ICT services considered in the country/region/industry should be collected from statistical data.
- Effects of ICT use: Data on the direct effects of ICT use at the macro level are needed from statistical data. How to calculate the direct effects of ICT is described in clause 11 and an example is given in Appendix II.

4) Calculation (see clause 11)

4-1) Calculating GHG emissions for a reference case using the basic CGE model:

The objective is to calculate GHG emissions and gross domestic product (GDP for a geographic area) or turnover (for an industrial domain) for the reference case. For the reference case, the basic CGE model shall be constructed on the basis of the input-output tables of the base year (initial conditions) and shall reproduce the economic equilibrium conditions of the base year. In this case, on the basis of the production activity and consumption activity, the model calculates energy consumption and GHG emissions generated by these activities.

4-2) Calculating GHG emissions for an ICT use case using advanced CGE model:

The objective is to calculate GHG emissions and GDP (for a geographic area) or turnover (for an industrial domain) for the ICT use case considered. For this ICT use case, in the evaluation period defined in step (1), improved production efficiencies as well as reduced investment in raw materials and energy are expected. This causes changes (reductions) in intermediate input coefficients for production activities, leading to decreases in price and consequently increases in the amount of production and demand for goods and services, which are one kind of rebound effect caused by ICT use.

The changes in intermediate input coefficients should be fed back to the input-output tables of the base year. The changes put the input-output tables temporarily out of equilibrium. An advanced CGE model should take these changes into account until economic equilibrium is regained. This new equilibrium state can be considered to be a state that has already reflected the economy-wide rebound effects caused by the use of ICT services. In this new equilibrium state, energy consumptions and GHG emissions caused by these services, the output of production sectors and the overall GDP/turnover shall be calculated for the ICT use case. Refer to clause 11 for details.

4-3) Calculating environmental and economic impacts of ICT use:

The objective is to calculate the differences for the various parameters (GHG emissions, GDP, etc.) between the reference case and the ICT use case as the effects of ICT use on the environment and economy.

5) Reporting (see clause 12)

A report shall be produced clearly documenting preconditions for the evaluation, the evaluation method, results and interpretation, including issues such as any uncertainties in the results.

8 Setting evaluation conditions

This step involves defining various preconditions for evaluation, including a time period of evaluation, a geographical scope of evaluation and the type of effects being evaluated. In particular, the following are defined.

– Time period (ordinarily one year): evaluation period and a baseline period for comparison.
– Type of ICT: primarily ICT services.
– Geographical scope for the evaluation, e.g., region, country or the world.
– Industrial domain, e.g., aeronautic, building or all industries included.
– Effects type being evaluated by ICT use, e.g., first order effects, second order effects, rebound effects, or others.

Since the model is calculated on the basis of input-output tables, time periods are basically the same as the period of input-output tables. This means that the time periods shall be set as one year for both the evaluation and baseline periods. To evaluate the effects of using ICT, a base year when the ICT was not used shall be set as a baseline for comparison and a year for which input-output tables are available for the evaluation region shall preferably be set as the base year. If input-output tables are not available for the base year, input-output tables can also be estimated by using a method such as the ratio allocation system (RAS) [b-Amer]. The evaluation year should be set as the year for which an evaluator wants to evaluate the effects of ICT use. The geographical scope, (e.g., a region, a country or the world) or the industrial domain shall also be clearly defined.

9 Constructing a CGE model

9.1 Basic CGE model

The objective is to construct a CGE model to evaluate the environmental and economic impacts caused by the use of ICT services. A CGE model expresses the structure of the economy and industry (input-output tables) as a set of simultaneous equations. A CGE model should be constructed for all goods and services sectors in the evaluation domain (geographical or industrial). Under the economic equilibria, levels of activities in each sector and prices for all goods, services and production factors are determined by a price mechanism. Production and consumption decisions are driven by the maximization of profits and utility, respectively. The equations also include a set of constraints that have to be satisfied by the system as a whole. The basic CGE model defined in this Recommendation is referred to in the Asia-Pacific Integrated Model/Computable General Equilibrium (AIM/CGE) model; see [b-NIES]. AIM/CGE models are part of a wider set of AIM models mentioned in the Intergovernmental Panel on Climate Change 5th assessment report (IPCC AR5) WG3 report as tools to assess the aggregated economic implications of transformation pathways.

9.1.1 Structure of the basic CGE model

The structure of the basic CGE model is shown in Figure 9-1. The final demand sector (households) holds the production factors of capital and labour, which are provided to the production sectors in exchange for income. The income received is used for purchasing consumer goods. Households maximize their utility in purchasing consumer goods. Production sectors (enterprises) use production factors, energy and raw materials to produce products and supply them to the market. In doing so, enterprises conduct production activities to maximize their profits on the basis of their production technologies. The supply and demand for goods and production factors are balanced in the market and levels of activity and the value of goods, services and production factors are determined so that supplier pricing and consumer pricing match. An example of a simple CGE model can also be referred to [b-Mitsutaka].

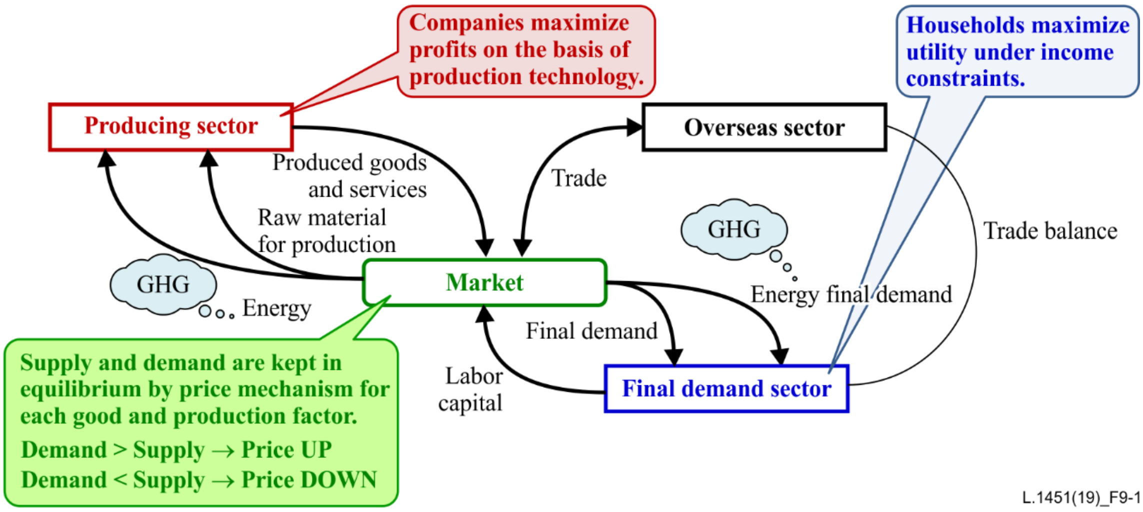

Figure 9-1 – Structure of the basic CGE model

9.1.2 Production activity, goods and services dealt with in the basic CGE model

It is desirable that the production activities, goods and services dealt with in the model basically conform to the categories in the input-output tables. However, production sectors and goods can also be subdivided or merged in accordance with the objectives of the analysis. An example for the activities (production sectors), goods and services dealt with in the basic CGE model based on the 2005 input-output tables in Japan is given in Appendix II.1.

9.1.3 Production sector

In production sectors, production activities are carried out by inputting intermediate inputs (intermediate goods and energy goods) and production factors (capital and labour). Each producer is assumed to maximize profits, defined as the difference between revenue earned and the cost of production factors and intermediate inputs. Figure 9-2 shows an example of a production structure. Both intermediate goods and energy goods are supplied by domestic goods and imported goods. Then, individual intermediate goods are merged into non-energy aggregated intermediate inputs by using Leontief functions. Individual energy inputs are merged into energy aggregated inputs by using Leontief functions. Capital and labour are merged in to added value by using Cobb-Douglas functions. Finally, all intermediate inputs, added value are merged to produce final outputs. Wastes are outputted as a minus value from production activities. The productions (outputs) are either exported or distributed domestically. GHG will occur when energy goods are used in production activities [b-NIES].

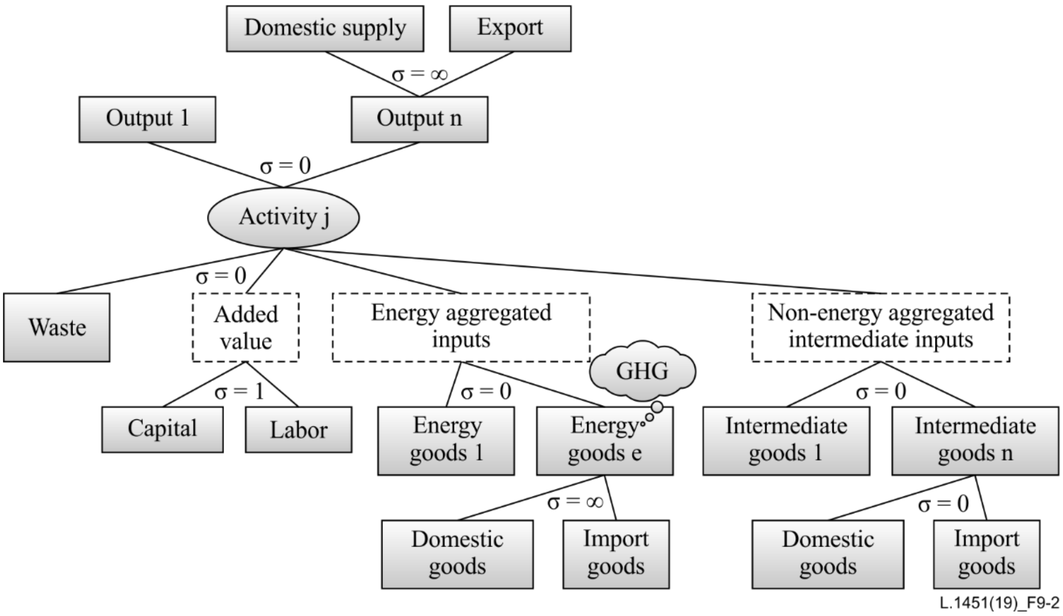

Figure 9-2 – An example of production structure

9.1.4 Final demand sector

The final demand sector for this model is defined to be the households sector. Figure 9-3 shows an example of a consumption structure. Households hold capital and labour and provide them to production sectors for income. They consume goods as final consumption. Utility is calculated from final consumption by using a Cobb-Douglas function and the purchase of consumptions is determined under maximum utility.

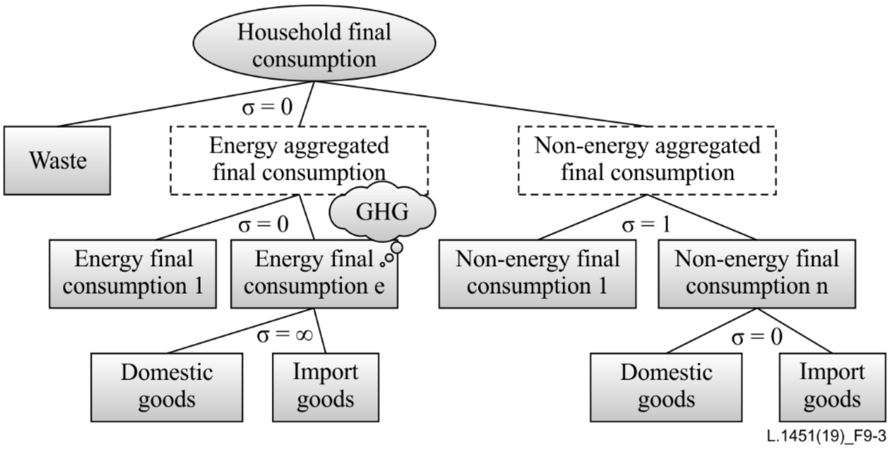

Figure 9-3 – An example of a consumption structure

9.2 Advanced CGE model for evaluating environmental effects of ICT use

This Recommendation defines an advanced CGE model for evaluating the impact of ICT use that is based on the AIM/CGE model. The advanced model should express changes due to the use of ICT services.

The structure of the advanced model is shown in Figure 9-4. The basic structure is the same as the basic CGE model shown in clause 9.1. The production and consumption activities consume energy and emit GHG. When ICT goods and services are used, the values of supply and demand for various goods (including energy commodities) change. These changes, including reductions or increases in intermediate inputs (intermediate goods and energy goods) and production factors (capital and labour), should be fed back to input-output tables for the base year and the outputs from production sectors and consumption in the final demand sector shall be calculated by the advanced CGE model until economic equilibrium is restored. Since the output and consumption has changed, energy used in the production sector and consumption sector will change. As a result, GHG emissions caused by energy use are also affected. The change in the energy use and these GHG emissions shall be calculated as environmental and economic impacts from the use ICT services.

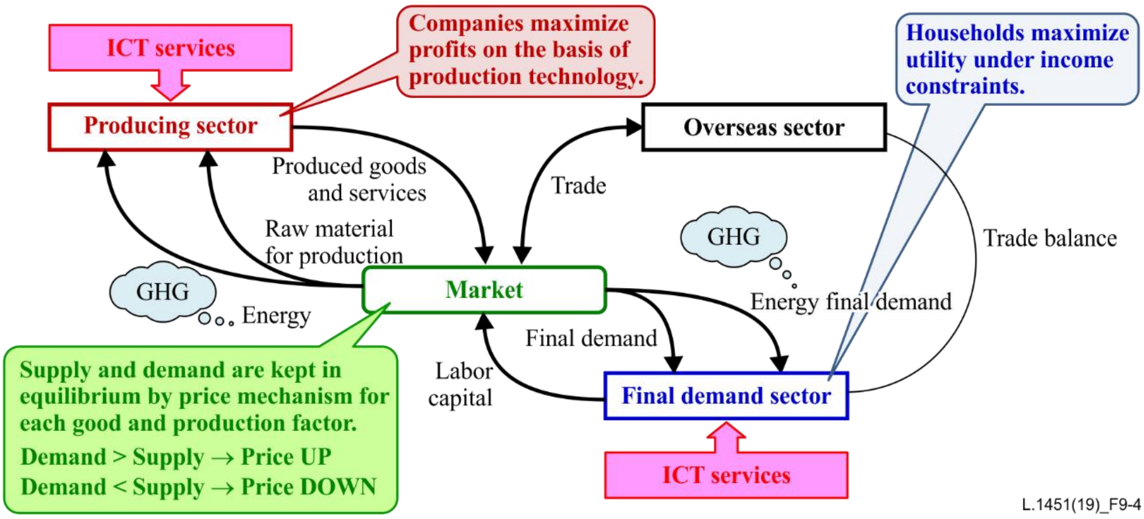

Figure 9-4 – Structure of the advanced CGE model for evaluating impacts of ICT use

10 Data collection

Several kinds of data are needed to evaluate the impacts of the use of ICT services. Highly reliable data from national statistics and ICT-related public organisations are recommended. If data is not available from such sources, data can also be collected from other sources, but their quality must be verified and the justification for using specific sources should be documented.

A) Basic input data for CGE model:

- Input-output tables: Basically, input-output tables in the evaluation region shall be collected, a social accounting matrix (SAM) shall be created on the basis of these input-output tables [b-OECD] and shall be used as input data to the model.
- Emission factors: In the CGE model, GHG emissions are calculated by multiplying the values of energy goods invested in the production sector and in the final consumption sector and GHG emission factors by energy type. Therefore, emission factors by energy type shall be collected.

B) Data related to ICT use:

- ICT penetration rates: Penetration rates of the ICT to be used in the evaluation country/region/industry shall be collected from statistical data for previous periods. If the evaluator wants to evaluate future impacts of ICT use, potential ICT penetration rates for future periods can also be set based on the evaluator's assumptions. For example, penetration rates of online banks may be considered as a usage rate of online bank accounts, which can be calculated by dividing the number of online bank accounts by the number of total bank accounts (including conventional bank accounts and online bank accounts).
- Data for setting the effects generated by the use of ICT services: Under the penetration of ICT services set above, data on the direct effects of the use of ICT services at the macro level are required as input data for the CGE model. For example, in production sectors, introducing ICT services can improve production efficiency, leading to a reduction of intermediate inputs such as material and energy. In this case, since direct

effects will be expressed as reduction rates of each intermediate input coefficient in the CGE model, data on types and percentage of intermediate inputs to be reduced shall be collected. Examples on how to set the direct effects are given in Appendix II.2. Direct effects should include changes in intermediate inputs and production factors.

11 Calculation of GHG emissions and GDP by CGE model

For a reference case, the basic CGE model should be based on the input-output tables of the base year (initial conditions) and it must reproduce the economic equilibrium conditions of the base year. In this case, on the basis of the production activity and consumption activity, the model calculates energy consumptions and GHG emissions caused by these activities. Also, the output of production sectors and the overall GDP (for a geographical area) or turnover (for an industrial domain) shall be calculated.

For an ICT use case in the evaluation year, the use of ICT services leads to improvements in production efficiencies and reductions in the amounts of used raw materials and energy through dematerialization. This produces changes in demands for intermediate inputs, goods and services. These changes should be fed back to the input-output tables of the base year, which puts the input-output tables temporarily out of economic equilibrium since the surplus resources caused by production efficiency and reduced intermediate inputs can be used in all industry sectors in the CGE model.

For example, for an enterprise producing certain types of goods, the amounts of intermediate inputs, e.g., labour, energy and raw materials before using a supply chain management (SCM) system are shown as the blue frame in Figure 11-1. When using an SCM, the production process will be optimized and the amounts of intermediate inputs will be reduced to the green frame (left figure). In this case, the price of the goods may decrease and the relationship between supply and demand may change. The demand for these goods may increase due to the decrease in price. Then the increase in the amount of goods may cause an increase in the intermediate inputs from the green frame to the red frame (right figure). The difference between the green and red frame can be considered as an economy-wide rebound effect caused by SCM use. These changes can be represented by an equilibrium calculation in the CGE model.

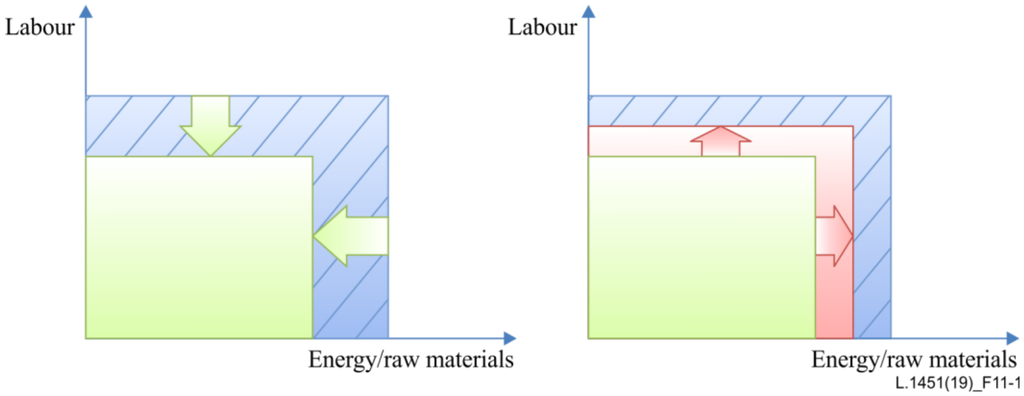

Figure 11-1 – Image of the changes caused by ICT use

The basic CGE model should show an economic equilibrium situation before ICT use. Then, when ICT is used in various sectors, the input-output tables are out of economic equilibrium and the advanced CGE model should be recalculated until economic equilibrium in the market is restored. Through the equilibrium calculation, the impact on the environment and economy, including economy-wide rebound effects caused by ICT use, will be evaluated using the CGE model.

The overall GDP/turnover and production activity in each sector should be calculated from the production activity in this new equilibrium, followed by the energy consumed and the resulting GHG emissions. Concrete steps when implementing the model are given below:

1) Set the ICT use cases to be evaluated. Determine the penetration rates of the ICT being evaluated. Penetration rates/quantities can be surveyed by various statistics or specific penetration conditions that an evaluator wants to evaluate.

2) Determine the effects of using ICT. Under the ICT penetration conditions set in (1), determine what kinds of effects could be considered by ICT use and quantify the effects. Effects considered in the evaluation could include the following:
   – reduction on intermediate inputs (goods and services dealt with in input-output tables), e.g., raw materials, energy used, space, utility expenses, etc. See Appendix II.1 for details.
   – reduction on production factors, such as, capital and labour, etc.

An example for determining the effects by using online banking services is shown in Appendix II.2.

3) Change the input coefficients to the advanced CGE model. Decide specifically which production activities, goods and services in the CGE model should be affected by the effects set in (2) and change the input coefficients in the advanced model in accordance with the effects. Examples on how to set input coefficient to CGE model are given in Appendix II.3.

4) Substitute the new input coefficients into the model and run the model until economic equilibrium is achieved once more. Then, the overall GDP/turnover, energy consumption and the resulting GHG emissions can be calculated by the model.

12 Reporting

Preconditions and interpretation of results shall be reported and a sensitivity analysis shall be made.

12.1 Preconditions

Preconditions shall be reported clearly when evaluating the impacts by this method. These are:

1) details for ICT use cases (e.g., ICT penetration rates, etc.);
2) direct effects of ICT use as inputs to the CGE model;
3) changes in intermediate input coefficients to the CGE model in the ICT use case;
4) sources for all input data sets used.

12.2 Output and analysis

A CGE model produces several kinds of evaluation results such as production amounts, energy consumption and GHG emissions in each sector for both the reference case and the ICT use case. The differences in production amounts, energy consumption and GHG emissions between the two cases shall be evaluated as the impacts of ICT use on the economy (GDP) or industrial sector (turnover) and the environment. Effects of individual ICT use, or total effects of several kinds of ICT, can also be output by the model.

The model can evaluate the effects of ICT use on each industry, including economy-wide rebound effects, by considering the economic equilibrium. Also, sensitivity analysis shall be done by setting different scenarios (e.g., ICT use cases). Thus the model is also helpful for identifying different ways for future societies to balance the economy and environment.

Appendix I

Framework for quantifying IT solutions' contributions to CO_2 emissions suppression – Umbrella method for calculation and aggregation

(This appendix does not form an integral part of this Recommendation.)

I.1 Background

The quantification of "Green by IT" (the "Green by IT" concept refers to energy saving in society via ICT solutions) is required in many situations.

One example would be where a vendor of IT solutions (hereafter referred to as the "IT solution vendor") seeks to present calculations of the effects that their IT solutions have on CO_2 emissions suppression to customers who implement them. Since CO_2 emissions are affected by a variety of factors including system configuration and usage, data regarding these factors must be gathered and the difference in CO_2 emissions before and after implementation must be compared in order to make these calculations. Another example would be where the IT solution vendor, having sold a specific IT solution, seeks to make calculations of the total annual suppression of CO_2 emissions for this particular solution. In such cases, it would not be easy to gather data regarding system configuration and usage for all shipped solutions to calculate their amount of CO_2 emissions suppression. To address this issue, it would be useful to prepare representative implementation scenarios for different types of IT solutions and estimate the amounts of CO_2 emissions being suppressed by multiplying these with parameters such as the number of solutions shipped. In other instances, the IT solution vendor may seek to calculate the total amount of CO_2 emissions being suppressed by a range of different solutions that they provide and visually represent the total amount of CO_2 emissions suppression from their products and services over a period of one or multiple years. In such cases again, certain rules and lines of thinking must be defined on how to carry out calculations and aggregation.

The quantification of CO_2 emissions suppression is also needed for verifying the status of efforts being taken by industry as a whole to counter global warming.

These published calculation methods have been designed to enable users to choose the appropriate method for their level of understanding. Moving forward, similar calculation methods must be developed for calculating the performance of other IT solutions.

Appendix I reviews Green by IT, specifically the framework for the quantification of CO_2 emissions suppression amounts (umbrella method for calculation and aggregation; hereafter referred to as "quantification framework") and summarizes the methods for quantifying the amounts of CO_2 emissions suppression, including simplified methods of calculation. Particularly Appendix I presents calculation methods for making simplified calculations for the amounts of CO_2 emissions being suppressed based on data that can be realistically gathered, without having to prepare detailed parameters or data. Details of these calculation methods are given in [b-CO_2 emissions suppression].

I.2 Overview

The implementation of IT solutions holds the promise of advancing greater efficiencies in business operations and activities and through this, contributing to the resolution of environmental issues faced by society at large. For example, the implementation of TV conferencing has the direct effect of reducing the number of business trips for those taking part in the conference and is also believed to reduce the amount of personal and vehicular travel, ultimately having the ripple effect of suppressing CO_2 emissions. For reasons such as this, in the context of countering global warming, there is an increasing need to make calculations of the amounts of CO_2 emissions that can be suppressed with the use of IT solutions.

The effects that IT solutions have in suppressing CO_2 emissions can be grouped into eight categories (hereafter referred to as "components"; see Table I.1). In each component, the differences in quantities that are affected by IT solution implementation (hereafter referred to as "activity quantity") multiplied by the coefficient that converts activity quantities to CO_2 emissions (hereafter referred to as "primary unit") constitutes the amount of CO_2 emissions being suppressed. Here, the primary unit constitutes CO_2 emissions per unit activity quantity based on the presumption that activity quantities and CO_2 emission amounts are proportional. In addition, the amount of CO_2 emissions suppression enabled by a particular IT solution can be calculated by totalling the amount of CO_2 emission suppression for each of the calculated components.

Table I.1 – Components of the effects of IT solutions and formulae for their calculation

Components	Component subjects	Component calculation formulae
(1) Consumption of material	Paper, CDs, books, etc.	Reduction in consumption of material x Primary unit of consumption of material
(2) Amount travelled by persons	Aircraft, automobiles, trains, etc.	Reduction in personal travel distance x Primary unit of travel
(3) Amount travelled by items	Trucks, railroad, cargo, etc.	Reduction in item travel distance x Primary unit of travel
(4) Office space	Space occupied by persons (including work efficiency), space occupied by IT equipment, etc.	Space reduction x Primary unit of energy consumption per space * Space reduction equals the number of persons reduced multiplied by the space occupied per person, or the number of pieces of equipment reduced multiplied by the space occupied per piece of equipment.
(5) Warehouse space	Warehouses, refrigerated warehouses, etc.	Space reduction x Primary unit of energy consumption per space
(6) Electricity and energy consumption (IT and network equipment)	Power consumed by servers, PCs, etc.	Amount of change in power consumption x Primary unit of grid power * This applies when converting electrical power into CO_2 emissions. * This represents the amount of energy consumed from the use of IT equipment, and does not include energy consumed for the manufacture or disposal of such equipment.
(7) Network data communication volume	Network data communication volume	Amount of change in data communication volume x Primary unit associated with data communication * The amount of energy consumed for network communications includes energy consumed for Internet communications, but not intranet communications.
(8) Other	Activities other than the above	Amount of change in activity x Primary unit of the amount of change

That being said, several issues exist with regard to actually calculating the amounts of CO_2 emissions being suppressed from the use of IT solutions. The first issue has to do with the difficulties in defining usage conditions before and after implementation. For example, in the implementation of TV conferencing systems, the number of user sites and users will typically vary from location to location, which makes it difficult to ascertain actual conditions. In order to quantify the reduction in personal travel enabled by TV conferencing, data will be needed on the variations in the number of individuals making business trips, as well as on travel distances covered on business trips. Data on the primary unit used for converting activity quantities into CO_2 emissions will also have to be gathered.

Calculators must either prepare primary units based on the power consumption of the railroad trains that are used for business trips and the greenhouse gas emissions coefficient of electrical power, or look up average primary units relating to personal travel. These types of data gathering tasks are rarely straightforward.

For this reason, the precision of the calculations is determined by the precision of the parameters and data that can be prepared. In cases where the calculator (IT solutions vendor, etc.) is able to prepare detailed parameters and data on their own, there is a greater chance that results from the calculation will be rigorous and cogent. Meanwhile, in cases where it is not straightforward for the calculator to prepare these parameters and data on their own, standard or hypothetical data that is generally available must be used, in which case the possibility that these calculations will yield rigorous and cogent results is highly questionable. Given this situation and based on the assumption that CO_2 emissions suppression amounts will be calculated according to [b-GIPC Explanatory Booklet], we have categorized the parameters and data that can be prepared into the levels shown in Figure I.1 according to their precision (calculation levels 1-3).

Indeed, because calculations for CO_2 emissions suppression amounts are difficult to carry out for the majority of IT solution vendors and other calculators even with the help of [b-GIPC Explanatory Booklet], there are requests for more straightforward methods of calculation. This appendix proposes a method for calculating amounts of CO_2 emissions being suppressed using data that can be realistically gathered without the need for preparing detailed parameters or data.

The objective is to enable more IT solution vendors and other calculators to use these calculation methods to calculate CO_2 emissions suppression amounts, and leverage this information in their business operations, as well as in their contributions to global warming countermeasures for society at large.

I.3 Framework for the quantification of CO_2 emissions suppression amounts

Figure I.1 shows a systematic schematic chart of the traditional methods for calculating CO_2 emissions suppression amounts based on [b-GIPC Explanatory Booklet]. The new simplified calculation method being proposed has been added to calculation level 3. This flow has been named the "Framework for the quantification of CO_2 emissions suppression amounts" and is commonly referred to as the "umbrella method".

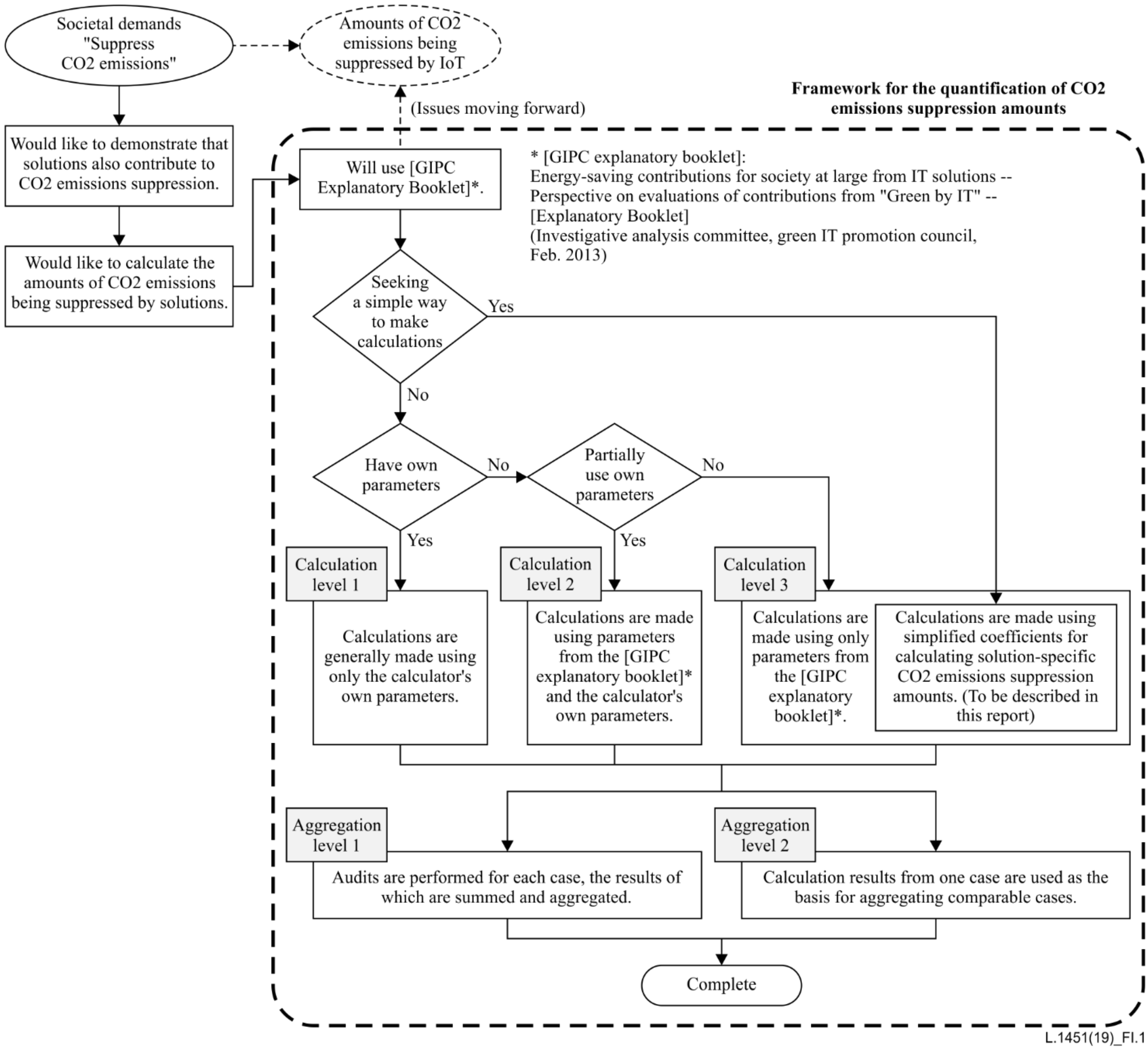

Figure I.1 – Framework for the quantification of CO_2 emissions suppression amounts

I.4 Simplified solution-specific coefficients for calculating CO_2 emissions suppression amounts

In this newly proposed simplified calculation method, the appendix has defined representative parameters that were aggregated from results of calculations previously made by member companies based on [b-GIPC Explanatory Booklet] and can be applied to calculations of solution-specific CO_2 emissions suppression amounts. These are referred to as the "simplified solution-specific coefficients for calculating CO_2 emissions suppression amounts" (hereafter referred to as "simplified calculation coefficients").

I.5 Calculation levels and aggregation levels

1) Calculation levels

We define "calculation levels" as shown in Table II.2. Based on the premise that CO_2 emissions suppression amounts will be calculated based on [b-GIPC Explanatory Booklet], calculation precision was categorized into calculation levels 1 to 3 to match the precision of the parameters and data that can be prepared. Calculation level 1 provides higher precision, and level 3 indicates lower precision. While the new simplified calculation method reviewed in this appendix is grouped in calculation level 3, the calculator must thoroughly examine whether the prepared activity quantities and other parameters are similar to those used in this method, in order to perform actual calculations. Even if the solution appears to be similar at first glance, the use of this method should be avoided if the calculator has any uncertainties.

2) Aggregation levels (Aggregation of calculated values)

"Aggregation levels" is defined as shown in Table I.3. The configurations and scale of IT solutions will be different from case to case even if they are of the same type (solutions that are used to solve the same problem). For this reason, although it would be ideal to sum up the values calculated for all solutions of the same type that are in use in our societies to accurately calculate the total amount of CO_2 emissions suppression by these solutions, this is unrealistic as it will involve too many man-hours. Simplified aggregations of values for representative solutions can be calculated by defining a coefficient, such as for scale, and multiplying it by n.

Additionally, this applies to the method for summing up the effects of solutions of different types (solutions with different solution objectives). For these reasons, this appendix goes only as far as to present the differences in aggregation levels and the issues thereof; it is up to the aggregator to decide which level at which to perform the aggregation.

Table I.2 – Calculation level definitions

<table>
<tr><th>Calculation level</th><th>Calculation method</th><th>Components of the effect to be calculated</th><th>Activity quantity</th><th>Primary unit</th></tr>
<tr><td>1</td><td>– The evaluator performs the calculation based on [b-GIPC Explanatory Booklet], taking into account the user's operations.
– Effects are calculated based on actual examples.</td><td>– Components are determined based on [b-GIPC Explanatory Booklet], taking into account the user's operations.
– Components are determined taking into account the states before and after implementation.</td><td>The evaluator defines the activity quantity according to the user's operations, and performs the calculations.</td><td>Primary units that the evaluator deems to be the most appropriate are used.</td></tr>
<tr><td>2</td><td rowspan="2">Using the information in this appendix, simplified CO_2 emissions suppression amounts are estimated and calculated based on similar examples.</td><td>Components are defined by combining, as needed, components that are made to match examples at different companies, and components that are defined in this appendix.</td><td>Calculations are made by choosing, as needed, activity quantities that are made to match examples at different companies, and activity quantities that are defined in this report.</td><td>Primary units that are made to match examples at different companies, and primary units that are defined in this appendix are chosen and used as needed.</td></tr>
<tr><td>3</td><td>Components that are defined in this report are used.</td><td>Calculations are made using activity quantities that are defined in this report.</td><td>Primary units that are defined in this report are used.</td></tr>
</table>

Table I.3 – Aggregation level definitions

Aggregation level	Aggregation method	Aggregation formula	Precision
1	Calculations are made for each case, and the results thereof are summed up and aggregated.	CO_2 emissions suppression amounts are calculated for each solution, and summed up.	Relatively high
2	Similar cases are aggregated based on calculation results from a single case.	Based on calculation results from a single case, representative examples including other cases are created from coefficients, activity quantities and other parameters, which are then summed up. Ex: One calculation result x n	Relatively low

I.6 Line of thinking behind the framework for the quantification of CO_2 emissions suppression amounts

In reference to the new "quantification framework" and solution-specific "simplified calculation coefficients" reviewed here, procedures for selecting appropriate calculation methods from among a number of methods have been organized in a comprehensive (umbrella) fashion in the quantification framework. In this clause, the line of thinking behind this organizing of procedures is discussed.

There were a broad range of applications for the quantification of CO_2 emissions suppression amounts, and calculation and aggregation levels will vary from application to application. The amount of data and man-hours required will vary considerably depending on the calculation or aggregation level. In the quantification framework, procedures have been summarized for selecting the appropriate method according to the application and data available.

Figure I.1 shows the procedures for selecting a method for quantifying CO_2 emissions suppression amounts. While there are many lines of thinking with regards to the calculation of CO_2 emissions suppression amounts, this quantification framework is based on the line of thinking behind the quantification of "Green by IT" CO_2 emissions suppression amounts that have been reviewed to date (see clause I.2 and reference document (7) in chapter 1 of [b-GIPC Explanatory Booklet], etc.) Characteristics of this method include the following:

– contributions (effects) to society at large from Green by IT are quantified;
– CO_2 emissions suppression effects are categorized in the form of the components shown in Table I.1, and consistent calculations are carried out;
– standard forms of primary units that are needed for calculations are provided for greater ease of use.

As such, in cases where an organization seeks to calculate the in-house energy costs of a customer and not those of society at large, a separate method of calculation must be used after changing boundary designations and other attributes.

Even in cases where the line of thinking behind [b-GIPC Explanatory Booklet] is applied, calculation methods and precision will vary widely depending on the available data and application. The quantification framework recommends that those methods (Figure I.1) that provide greater precision (level 1, etc.) should be the first to be reviewed.

For example, in applications that require high levels of precision, and where primary units and data such as representative values can be gathered independently, it is recommended that calculations be carried out based on [b-GIPC Explanatory Booklet] (level 1). That being said, there are many cases where it can be difficult to gather all primary units or data on representative values. Also, in some cases, a solution may be expected to provide a unique type of CO_2 emissions suppression effect owing to its unique functions, or its primary unit may be considerably different from standard values.

In such cases, it is preferable to selectively use the standard primary units and representative values listed in [b-GIPC Explanatory Booklet] and use the unique effects and data in addition to perform calculations (calculation level 2). Finally, there may be cases where it is difficult to gather representative values, or where a simple way of calculating approximated CO_2 emissions suppression amounts is sought. In such cases, a method for calculating approximated CO_2 emissions suppression amounts based on solution-specific "simplified calculation coefficients," which have been created from the representative usage and primary unit for the solution (calculation level 3), can be chosen. That being said, since calculation level 3 is a simplified method of calculation and results from this method are likely to contain large margins of error, we have been conservative with CO_2 emissions suppression amounts in the process of deriving these solution-specific "simplified calculation coefficients".

In cases where calculations that incorporate individual conditions are sought, it would be most appropriate to consider level 2 calculations.

We believe that, by using these procedures to select calculation and aggregation methods, users will be able to choose the appropriate calculation and aggregation methods from among many other methods.

I.7 Overview of the simplified calculation coefficient

In the quantification framework, a simplified calculation of CO_2 emissions suppression amounts can be made using the simplified calculation coefficients presented in this report, based on parameters such as the number of IT solutions shipped. All of the "components of the effect to be calculated," "activity quantities," and "primary units" that have been used to derive these coefficients come from representative model values based on data from examples that we have gathered. We include this as one method of calculation in calculation level 3.

Because a representative scenario is a prerequisite for deriving these coefficients, the decision whether or not to apply them must come from reviews on how similar a scenario is to the actual state of implementation or the form of solution. If the actual state of implementation is deemed to be not similar to the defined scenario, the use of this calculation method should be avoided.

In deriving these coefficients, examples from member companies were gathered, and aggregated into representative system configurations and implementation scenarios. Parameters that may affect CO_2 emissions suppression amounts (number of locations or shops where the solution is implemented, etc.) were also considered.

Table I.4 lists reviewed IT solutions.

Table I.4 – IT solutions reviewed

Category		No.	IT solution (GIPC version)	Solutions for which simplified calculation coefficients were reviewed in this report
Industry	Factory	1	FEMS (factory energy management system)	–
	Production	2	Greater efficiency for lighting, air conditioning, motors and generators	–

Table I.4 – IT solutions reviewed

Category		No.	IT solution (GIPC version)	Solutions for which simplified calculation coefficients were reviewed in this report
		3	Greater efficiency in production processes	Greater efficiency in production processes
Operation	Building	4	BEMS (building energy management system)	BEMS
	Indoors	5	Electronic tags, logistics systems	–
		6	Paperless office	Paperless office
		7	Implementation of IT in operations (e-Learning, etc)	Delivery management systems e-Learning
		8	Teleworking	Teleworking
		9	TV conferencing [remote conferencing system]	TV conferencing
		10	Remote medicine, electronic medical records	Remote consultation
		11	Electronic bidding, electronic applications	Electronic procurement
Home	Building	12	HEMS (home energy management system)	–
	Indoors	13	Electronic money	–
		14	Electronic publishing, electronic applications	Electronic publishing, electronic applications
		15	Music distribution, software distribution	–
		16	Online shopping	–
Transport	Infrastructure	17	Traffic light conversion to LED (Smart application)	–
	Activities	18	ITS (intelligent transport system)	–
		19	Improve automobile fuel consumption	–
		20	Greater efficiency in modes of transportation	–
		21	Eco-driving [digital tachograph systems]	Eco-driving
Operation	Additional*	22	Tape storage	Tape storage
Other		23	Solutions other than the above	
NOTE – IT solutions shown in grey-shaded rows are examples reviewed in the appendix.				

I.8 Results of simplified calculation coefficient derivation

Simplified calculation coefficients were derived for other types of solutions just as was done for TV conferencing systems. In the example of TV conferencing, it was deemed that the CO_2 emissions suppression amount was proportionate to the number of systems supplied to the market. However, because the proportional relationship between specific parameters and the amount of CO_2 emissions suppression will vary from solution to solution, reviews were carried out for each solution and the relevant parameters were presented as "basic units" (number of clients, number of shops, number of target individuals, etc.).

Table I.5 shows a summary of the results of deriving the simplified calculation coefficient and the solution-specific basic units that we have reviewed.

The representative values and units shown in the table are the simplified calculation coefficients for each solution. If a particular solution is similar to one shown in Table I.5, the approximate amount of CO_2 emissions suppression for that solution can be calculated by acquiring the number of clients, sites, shops and other data relating to the solution's implementation and multiplying them by the representative values shown in Table I.5.

Table I.5 – List of solution-specific simplified calculation coefficients

Categories		**IT solution**				**Basic unit**	**Simplified calculation coefficient**	**Unit**
Broad category	**Sub-category**	**IT solution category**	**Solution**		**Class, conditions**			
Industry	Production process	Greater efficiency in production processes	Quality control operations solution		–	Client	4	kg-CO_2/(client year)
Operation	Building	BEMS (building energy management system)	BEMS (building energy management system)		Floor area 10,000m² or greater*1	m²	1.1	kg-CO_2/(m² year)
					Floor area less than 10,000m²*2	m²	0.45	kg-CO_2/(m² year)
	Indoors	Paperless office	e-document solution		Small rate of paper consumption	Shop	1,200	kg-CO_2/(shop year)
		Paperless office	Electronic forms		Large rate of paper consumption	Shop	2,000	kg-CO_2/(shop year)
		Delivery management system	Customer and delivery destination information management system		–	Client	110	kg-CO_2/(client year)
		e-Learning	e-Learning system (remote learning system)		–	Client	60	kg-CO_2/(client year)

*1 Presumes the effects of BEMS equipped with control functions.

*2 Presumes the effects of BEMS through the visualization of energy usage.

Table I.5 – List of solution-specific simplified calculation coefficients

Categories		IT solution				Basic unit	Simplified calculation coefficient	Unit
Broad category	**Sub-category**	**IT solution category**	**Solution**		**Class, conditions**			
		Teleworking	Teleworking		–	Client	200	kg-CO_2/(client year)
		TV conferencing (remote conferencing)	TV conferencing (regular definition)		Regular definition	Site	390	kg-CO_2/(site year)
			TV conferencing (high definition)		High definition	Site	140	kg-CO_2/(site year)
		Remote medicine, electronic medical records	Remote consultation		–	Number of target individuals	4	kg-CO_2/(person year)
		Electronic procurement	Central management solution for administrative work		–	Client	7,000	kg-CO_2/(client year)
Home	Indoors	Electronic publishing, electronic applications	Solution for managing administrative rules		–	Client	4,000	kg-CO_2/(client year)
Transport	Activity	Eco-driving	Digital tachograph		–	Client	2,100	kg-CO_2/(client year)
Operation	–	Tape storage	Tape storage system		Archive data 400TB	Site	9,000	kg-CO_2/(site year)

I.9 Calculation procedures (choosing the appropriate method of calculation)

Depending on the purpose of calculating the amounts of CO_2 emissions suppression, the appropriate calculation level shall be chosen according to the flow shown in Figure I.1.

In cases where the calculator is able to prepare the parameters and data to use for the calculation, calculation level 1 or 2 may be used. In cases where it is difficult for the calculator to prepare parameters and data on his/her own, calculations shall be made using calculation level 3. To make simplified calculations, the simplified calculation coefficients presented in this appendix (Table I.5) shall be used, and the calculation level will be 3. However, because simplified calculation coefficients are currently not available for solutions other than those shown in Table I.5, the calculator will need to make calculations based on [b-GIPC Explanatory Booklet] as needed.

(Step 1) If independent data on the primary unit, usage of the implemented system and system configuration are sufficiently available, consider whether calculation levels 1 or 2 can be used.

- Level 1 applies to cases where all of the data, including primary units, can be gathered independently.
- Level 2 applies if the calculation will partially use primary units and other values presented in this report.

– For details, see the calculation methods shown towards the end of this appendix and [b-GIPC Explanatory Booklet].

(Step 2) If independent data on the primary unit, usage of the implemented system, and system configuration are not sufficiently available, consider whether calculation level 3 can be used.

– You will need to have data that are in line with the parameters presented in [b-GIPC Explanatory Booklet].

– Calculations using simplified calculation coefficients are also an option. (See clause I.10)

(Step 3) If the calculator seeks to make provisional calculations of approximate values, and is unable to prepare sufficient data in Step 2, consider using the simplified calculation coefficients.

– The calculator will need to prepare data (number of shops, etc.) that can be applied to Table I.5 (See clause I.10).

I.10 Calculation procedure using simplified calculation coefficients

(Step 1) From the solutions listed in Table I.5, choose a solution that you wish to make calculations for.

(Step 2) Consider whether or not the applicable solution in Table I.5 and the solution that you seek to make calculations for are similar. Their similarity shall be determined based on the "similarity of solution configuration and purpose" and "similarity of effects (eight effects) that result from the solutions' specifications." Results of this determination are dependent on the calculator.

NOTE 1 – Compare the descriptions of solutions in Table I.5 ("Overview" "Configuration and CO_2 emissions suppression effects of representative solutions") and the solution that you seek to make calculations for, to consider whether or not they are similar.

NOTE 2 – Consider whether effects similar to the "CO_2 emissions suppression effects" attributed to solutions in Table I.5 can be expected from the solution that you seek to make calculations for.

NOTE 3 – If the solutions can be deemed to be not similar, consider whether calculations can be made at level 1 or 2 based on [b-GIPC Explanatory Booklet].

I.11 Specific aggregation procedures

Several scenarios are conceivable for summing up the CO_2 emissions suppression enabled by multiple solutions.

– summing up the effects of solutions of the same type;

– summing up the effects of solutions of different types;

– summing up the effects of solutions supplied by more than one vendor;

– a mixture of the above.

Appendix II

Examples for using the CGE model

(This appendix does not form an integral part of this Recommendation.)

II.1 Example for the activities, goods and services dealt with in the basic CGE model

In Appendix II.1, Table II.1 shows an example for the activities, goods and services dealt with in the basic CGE model based on the 2005 input-output tables in Japan [b-IOTs for Japan].

Table II.1 – Activities, goods and services dealt within the basic CGE model

Activities (production sector)	Goods/Services
1 Agriculture, forestry and fishery	1 Agriculture, forestry and fishery
2 Mining	2 Mining
3 Coal, oil, gas	3c Coal
	3o Oil
	3g Gas
4 Beverages and foods	4 Beverages and foods
5 Textile products	5 Textile products
6 Pulp, paper and wooden products	6 Pulp, paper and wooden products
7 Chemical products	7 Chemical products
8 Petroleum products	8 Petroleum products
9 Coal products	9 Coal products
10 Plastic and Gum	10 Plastic and Gum
11 Ceramic, stone and clay products	11 Ceramic, stone and clay products
12 Iron and steel	12 Iron and steel
13 Non-ferrous metals	13 Non-ferrous metals
14 Metal products	14 Metal products
15 General machinery	15 General machinery
16 Electrical machinery	16 Electrical machinery
17 Commercial Machinery	17 Commercial Machinery
18 Electronic components	18 Electronic components
19 Electromechanical	19 Electromechanical
20 Information and communication electronics equipment	20 Information and communication electronics equipment
21 Transportation equipment	21 Transportation equipment
22 Miscellaneous manufacturing products	22 Miscellaneous manufacturing products
23 Construction	23 Construction
24 Electricity supply	24 Electricity
24n Nuclear	
24t Thermal	
24h Others	
25 Gas supply	25 Gas supply
26 Heat supply	26 Heat supply
27 Water supply	27 Water supply
28 Waste disposal business	28 Waste disposal business
29 Commerce	29 Commerce
30 Finance and insurance	30 Finance and insurance
31 Real estate	31 Real estate
32 Transport and post	32 Transport and post
33 Information and communications	33 Information and communications

Table II.1 – Activities, goods and services dealt within the basic CGE model

Activities (production sector)	Goods/Services
34 Public administration	34 Public administration
35 Education and research	35 Education and research
36 Medical service, health, social security and nursing care	36 Medical service, health, social security and nursing care
37 Other public services	37 Other public services
38 Business services	38 Business services
39 Personal services	39 Personal services
40 Office supplies	40 Office supplies
41 Activities not elsewhere classified	41 Activities not elsewhere classified

II.2 Example of setting the effects of using ICT

Appendix II.2 explains how to set the effects of ICT use in production sectors and demand sectors. Online banking is taken as an example of an ICT service. The direct effects in the evaluation year 2013 compared to the base year 2005 for online banking use are shown as follows:

First, environmental effects generated by the use of online banking: reduction in movement of online banking users and reduction in the number of bank branches.

a) Reduction in movement of online banking users

Before starting to use online banking, customers are assumed to have physically contacted a bank (by bicycle, by automobile or by train). Avoiding the use of automobiles or trains reduces GHG emissions, so this effect will be evaluated in the model.

First, as shown in Figure II.1, the total number of times online bank accounts are used in one year (C) is calculated by multiplying the number of online bank accounts (A) and the number of usages per account in one year (B). Then, the total movement distance by users to the bank (E) can be calculated by multiplying the average movement distance to a bank per use (D) and the total number of times online bank accounts are used in one year (C). Next, this total movement distance by users to the bank (E) is multiplied by the train proportion (F1) and automobile proportion (F2) to obtain the reduction in train movement (G1) and the reduction in automobile movement (G2). Finally, the annual reductions in train passenger transport and automobile transport (K1, K2) due to use of banking can be calculated by dividing both movement reductions (K1, K2) by the annual passenger train transport (H1) and automobile transport (H2) amounts, respectively.

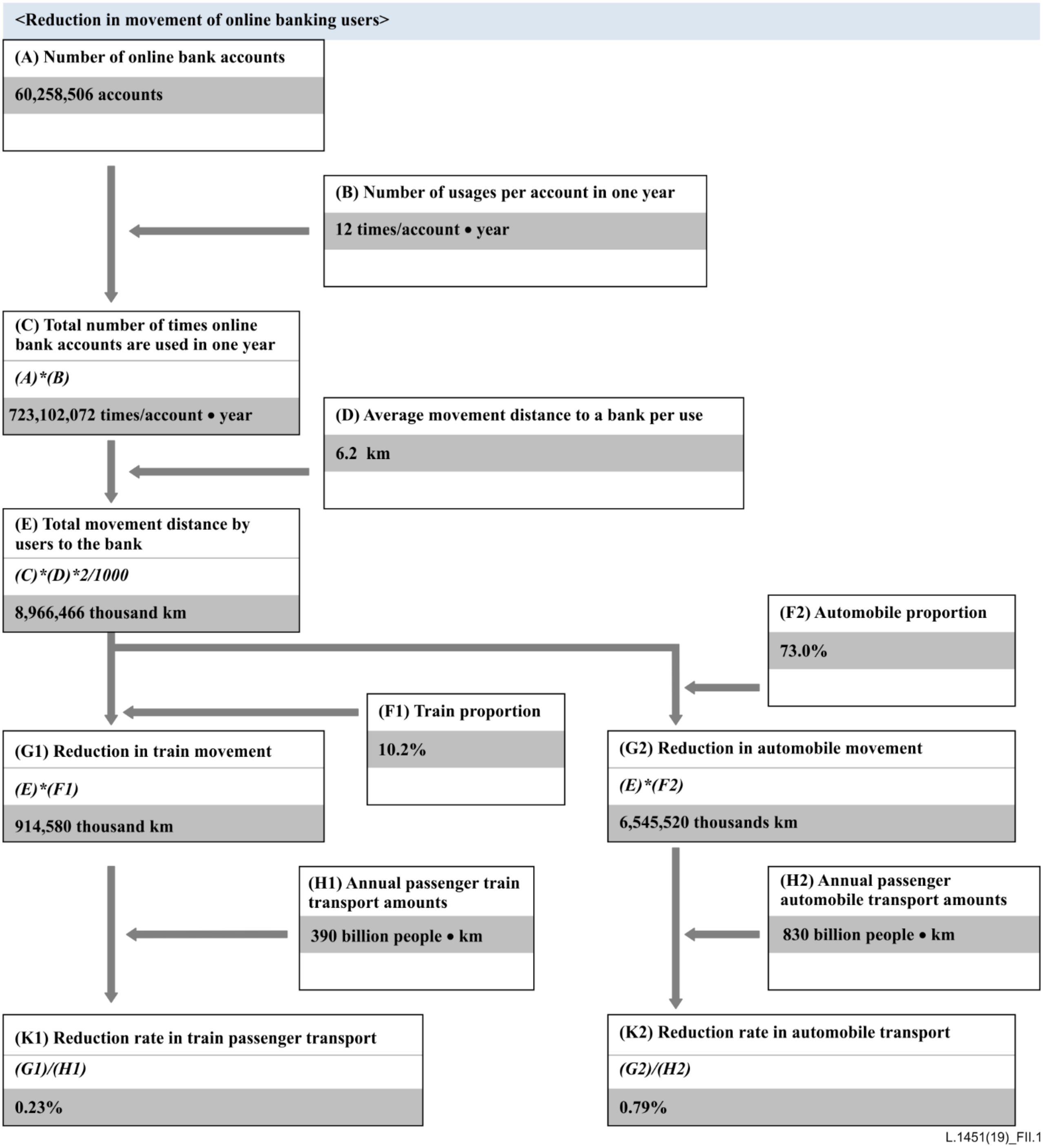

Figure II.1 – Reduction rate in user movement of online banking use

b) Reduction in bank branches

As shown in Figure II.2, the reduction on the number of branches of financial institutions (U) is calculated by the difference in the number of branches in the base year (Y1) and the number of branches in the evaluation year (Y2). The number of branches of financial institutions can be obtained from the Center for Financial Industry Information Systems white paper. Then reduction rate (R) can be calculated by dividing (U) and (Y).

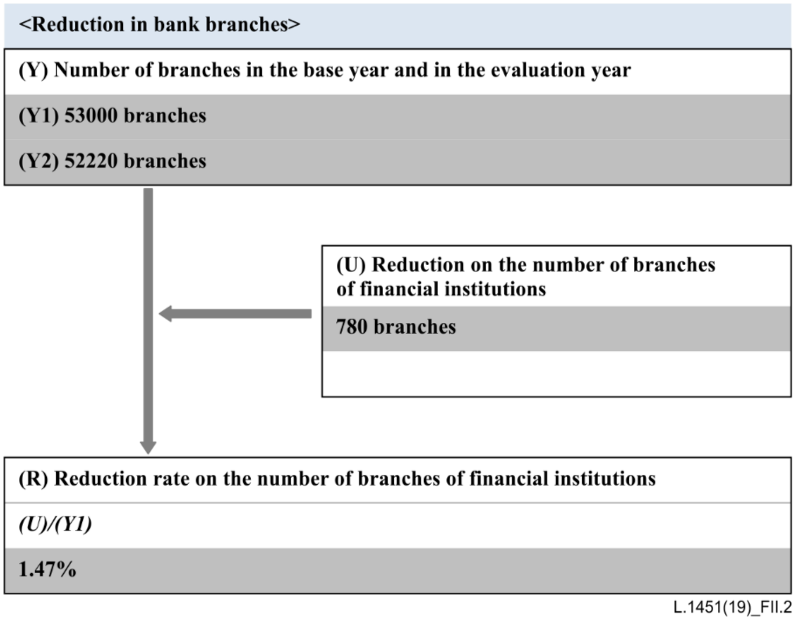

Figure II.2 – Reduction rates in bank branches of online banking use

Data sources are shown in Table II.2

Table II.2 – Data sources

Data	Source
(A) Number of online bank accounts	2013 Center for Financial Industry Information Systems white paper
(B) Number of usages per account in one year	Estimated from 2012 survey by the Japanese Bankers Association
(D) Average distance to the nearest bank	Kitakyushu person-trip survey (2008)
(F1)(F2) Train, automobile proportions	Movements of people in urban areas, from 2010 National Survey of Urban Transportation Characteristics, aggregate results
(H1) Annual passenger train transport	Ministry of Land, Infrastructure and Transport / Train transport statistics annual report
(H2) Annual automobile transport	Ministry of Land, Infrastructure and Transport
(Y1) (Y2) Total number of bank branches	2013 Center for Financial Industry Information Systems white paper

II.3 Example of conversion method on coefficients input to CGE model to express effects of ICT use

To express the effects of ICT use on the production sectors and consumption sectors determined in clause 11, the coefficients input to the CGE model should be converted as follows:

Reduction in automobile transport due to online banking use is expressed as a reduction in household expenditure in fossil fuel products (gasoline and diesel) in the final demand sector. The reduction in train transport by online banking use is expressed as a reduction in household expenditure on transport (train transport) in the final demand sector. Also, the reduction in the number of branches is expressed as a reduction in the input coefficients of real estate, fuel and lighting expenses in the financial sector. These changes applied to the model input coefficients are shown in Table II.3.

Before online banking services are used, all the input coefficients are set to 1 in the base year 2005. When online banking services are used (as shown in Table II.3), the input coefficients from the transport/post sector and petroleum products sector (fossil fuel consumed by private cars) to the private final consumption expenditure sector, and input coefficients from the electricity sector, gas supply sector, heat supply sector, water supply sector, waste disposal business sector and real estate sector to the finance and insurance sectors are all decreasing.

For example, the input coefficients from "24 row electricity sector" to "30 column finance and insurance sector" decreased from 1 to 0.990. These means production activities can be performed with fewer intermediate inputs. Then the surplus resource (e.g., surplus electricity) can also be used in other production activities of other industry sectors. These effects will extend to all production and consumption sectors and can be assessed quantitatively with the CGE model by equilibrium calculation.

Table II.3 – Changes to CGE model input coefficients for use of online banking (assuming 1 for 2005 reference data)

	1 Agriculture forestry and fishery	2 Mining	...	29 Commerce	30 Finance and insurance	31 Real estate	...	41 Activities not elsewhere classified
1 Agriculture, forestry and fishery	1	1		1	1	1		1
2 Mining	1	1		1	1	1		1
3c Coal	1	1		1	1	1		1
3o Oil	1	1		1	1	1		1
3g Gas	1	1		1	1	1		1
4 Beverages and foods	1	1		1	1	1		1
5 Textile products	1	1		1	1	1		1
6 Pulp, paper and wooden products	1	1		1	1	1		1
7 Chemical products	1	1		1	1	1		1
8 Petroleum products	1	1		1	1	1		1
9 Coal products	1	1		1	1	1		1
10 Plastic and Gum	1	1		1	1	1		1
11 Ceramic, stone and clay products	1	1		1	1	1		1
12 Iron and steel	1	1		1	1	1		1
13 Non-ferrous metals	1	1		1	1	1		1
14 Metal products	1	1		1	1	1		1
15 General machinery	1	1		1	1	1		1
16 Electrical machinery	1	1		1	1	1		1
17 Commercial machinery	1	1		1	1	1		1
18 Electronic components	1	1		1	1	1		1
19 Electromechanical	1	1		1	1	1		1
20 Information and communication electronics equipment	1	1		1	1	1		1
21 Transportation equipment	1	1		1	1	1		1
22 Miscellaneous Manufacturing products	1	1		1	1	1		1
23 Construction	1	1		1	1	1		1
24 Electricity	1	1		1	0.990	1		1
25 Gas supply	1	1		1	0.993	1		1
26 Heat supply	1	1		1	0.990	1		1
27 Water supply	1	1		1	0.991	1		1
28 Waste disposal business	1	1		1	0.992	1		1
29 Commerce	1	1		1	1	1		1

Table II.3 – Changes to CGE model input coefficients for use of online banking (assuming 1 for 2005 reference data)

	1 Agriculture forestry and fishery	2 Mining	...	29 Commerce	30 Finance and insurance	31 Real estate	...	41 Activities not elsewhere classified
30 Finance and insurance	1	1		1	1	1		1
31 Real estate	1	1		1	0.990	1		1
32 Transport and post	1	1		1	1	1		1
33 Information and communications	1	1		1	1	1		1
34 Public administration	1	1		1	1	1		1
35 Education and research	1	1		1	1	1		1
36 Medical service, health, social security and nursing care	1	1		1	1	1		1
37 Other public services	1	1		1	1	1		1
38 Business services	1	1		1	1	1		1
39 Personal services	1	1		1	1	1		1
40 Office supplies	1	1		1	1	1		1
41 Activities not elsewhere classified	1	1		1	1	1		1
Consumption expenditure outside households	1	1		1	1	1		1
Compensation of employees, payable	1	1		1	1	1		1
Social insurance premiums	1	1		1	1	1		1
Operating surplus and mixed income, net	1	1		1	1	1		1
Indirect taxes	1	1		1	1	1		1
Subsidy	1	1		1	1	1		1
Gross domestic product	1	1		1	1	1		1

Table II.3 – (continued)

	Private final consumption expenditure	Government final consumption expenditure	Gross fixed capital formation by private sectors	Gross fixed capital formation by public sectors	Changes in inventories	Export	Export tax	Import	Import tax	Gross domestic product
1 Agriculture, forestry and fishery	1	1	1	1	1	1	1	1	1	1
2 Mining	1	1	1	1	1	1	1	1	1	1
3c Coal	1	1	1	1	1	1	1	1	1	1
3o Oil	1	1	1	1	1	1	1	1	1	1
3g Gas	1	1	1	1	1	1	1	1	1	1
4 Beverages and foods	1	1	1	1	1	1	1	1	1	1
5 Textile products	1	1	1	1	1	1	1	1	1	1
6 Pulp, paper and wooden products	1	1	1	1	1	1	1	1	1	1
7 Chemical products	1	1	1	1	1	1	1	1	1	1
8 Petroleum products	0.994	1	1	1	1	1	1	1	1	1
9 Coal products	1	1	1	1	1	1	1	1	1	1
10 Plastic and Gum	1	1	1	1	1	1	1	1	1	1

Table II.3 – (continued)

	Private final consumption expenditure	Government final consumption expenditure	Gross fixed capital formation by private sectors	Gross fixed capital formation by public sectors	Changes in inventories	Export	Export tax	Import	Import tax	Gross domestic product
11 Ceramic, stone and clay products	1	1	1	1	1	1	1	1	1	1
12 Iron and steel	1	1	1	1	1	1	1	1	1	1
13 Non-ferrous metals	1	1	1	1	1	1	1	1	1	1
14 Metal products	1	1	1	1	1	1	1	1	1	1
15 General machinery	1	1	1	1	1	1	1	1	1	1
16 Electrical machinery	1	1	1	1	1	1	1	1	1	1
17 Commercial machinery	1	1	1	1	1	1	1	1	1	1
18 Electronic components	1	1	1	1	1	1	1	1	1	1
19 Electromechanical	1	1	1	1	1	1	1	1	1	1
20 Information and communication electronics equipment	1	1	1	1	1	1	1	1	1	1
21 Transportation equipment	1	1	1	1	1	1	1	1	1	1
22 Miscellaneous Manufacturing products	1	1	1	1	1	1	1	1	1	1
23 Construction	1	1	1	1	1	1	1	1	1	1
24 Electricity	1	1	1	1	1	1	1	1	1	1
25 Gas supply	1	1	1	1	1	1	1	1	1	1
26 Heat supply	1	1	1	1	1	1	1	1	1	1
27 Water supply	1	1	1	1	1	1	1	1	1	1
28 Waste disposal business	1	1	1	1	1	1	1	1	1	1
29 Commerce	1	1	1	1	1	1	1	1	1	1
30 Finance and insurance	1	1	1	1	1	1	1	1	1	1
31 Real estate	1	1	1	1	1	1	1	1	1	1
32 Transport and post	0.999	1	1	1	1	1	1	1	1	1
33 Information and communications	1	1	1	1	1	1	1	1	1	1
34 Public administration	1	1	1	1	1	1	1	1	1	1
35 Education and research	1	1	1	1	1	1	1	1	1	1
36 Medical service, health, social security and nursing care	1	1	1	1	1	1	1	1	1	1
37 Other public services	1	1	1	1	1	1	1	1	1	1
38 Business services	1	1	1	1	1	1	1	1	1	1
39 Personal services	1	1	1	1	1	1	1	1	1	1
40 Office supplies	1	1	1	1	1	1	1	1	1	1
41 Activities not elsewhere classified	1	1	1	1	1	1	1	1	1	1
Consumption expenditure outside households										
Compensation of employees, payable										
Social insurance premiums										

Table II.3 – (continued)

	Private final consumption expenditure	Government final consumption expenditure	Gross fixed capital formation by private sectors	Gross fixed capital formation by public sectors	Changes in inventories	Export	Export tax	Import	Import tax	Gross domestic product
Operating surplus and mixed income, net										
Indirect taxes										
Subsidy										
Gross domestic product										

Appendix III

Other aspects of aggregated positive ICT impact assessments

(This appendix does not form an integral part of this Recommendation.)

When determining the activities benefitting from the use of the assessed ICT services, the first step is to consider the relevant core business and horizontal activities.

The core business activities are critical and closely linked to the business strategy of the company using the ICT services as a direct response to customers' demands. It should be noted that these core activities for a specific company might not be core activities for other companies.

Horizontal activities relate to processes needed in all organizations to manage business activities. Examples are accounting, marketing, R&D and HR departments.

For each of these activities, two important aspects should be considered as priorities according to [b-OECD Greener]:

– Optimization: ICTs can reduce another product's environmental impact. Examples include embedded systems in cars for fuel-efficient driving, "smart" electricity distribution networks to reduce transmission and distribution losses, and intelligent heating and lighting systems in buildings which increase their energy efficiency.
– Dematerialization and substitution: Advances in ICTs and other technologies facilitate the replacement of physical products and processes by digital products and processes. For example, digital music may replace physical music media and teleconferences may replace business travel.

Table III.1 shows the main types of positive effects on the production life cycle and on the products and distribution systems (dematerialization, substitution of information goods for material goods, and substitution of communication at a distance for travel).

Table III.1 – Effects on production life cycle and products and distribution systems

Area	Potential environmental impact	Examples
R&D and design	Positive (Optimization)	Computer-aided design, 3D printing
Production	Positive (Optimization)	Computer-integrated manufacturing, complexity and size reduction of ICT products, supply-chain management.
Use	Positive (Optimization)	"Smart" technologies, e.g., intelligent heating, cooling and ventilation, electricity distribution, embedded systems and software in cars.
	Positive (Dematerialization)	Digital music replacing purchases of physical music media; telework replacing commutes.
Distribution	Positive (Optimization)	Logistics management.
End-of-life	Positive (Optimization)	Smart sorting for recycling; design for reuse and recyclability; waste tracking.

A business as usual (BAU) scenario is defined as a view of a future situation without any implemented changes. The objective is to provide a realistic description of how the business activity may develop based on a coherent set of assumptions if the new IT solutions would be not put in place. However, future impacts of ICTs and their environmental repercussions are relatively difficult to forecast, mainly because of the complexity of assessing future directions of production and consumption. In this context, the study should clearly indicate the assumptions used to evaluate the impacts of future scenarios, as well as the level of uncertainties relating to the data.

If the current situation is already based on IT solutions and the practitioner needs to define a pre-introduction scenario and recalculate the positive implementation of these IT solutions. A pre-introduction scenario is often uncertain because a pre-introduction scenario is hypothetical and intangible and several scenarios are possible before introduction.

Basically, it consists in subtracting the ICT current impacts, as calculated with [ITU-T L.1410], from the impacts estimated for the BAU scenario.

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Printed in Switzerland
Geneva, 2020