# CGE Modeling in Korea:
## Past, Present, and Future

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# Contents

# I. Introduction

CGE modeling is useful for feedbacks and heterogenous behavior of agents

CGE Model: Computable General Equilibrium Model

- Computable – data intensive, theoretical background

- General – feedbacks, multi-sectoral, heterogeneity

- Equilibrium – prices adjust to clear markets (a la Walras)

CGE Model becomes the preferred tool of economic analysis for governments, and policy makers to evaluate the general economy-wide impacts of proposed policy changes

Recent advances have also allowed CGE modelers to work in areas besides policy impact analysis

# A. Database: Benchmark Equilibrium

SAM is a matrix representation of the national accounts

- It serves as a database for CGE Model

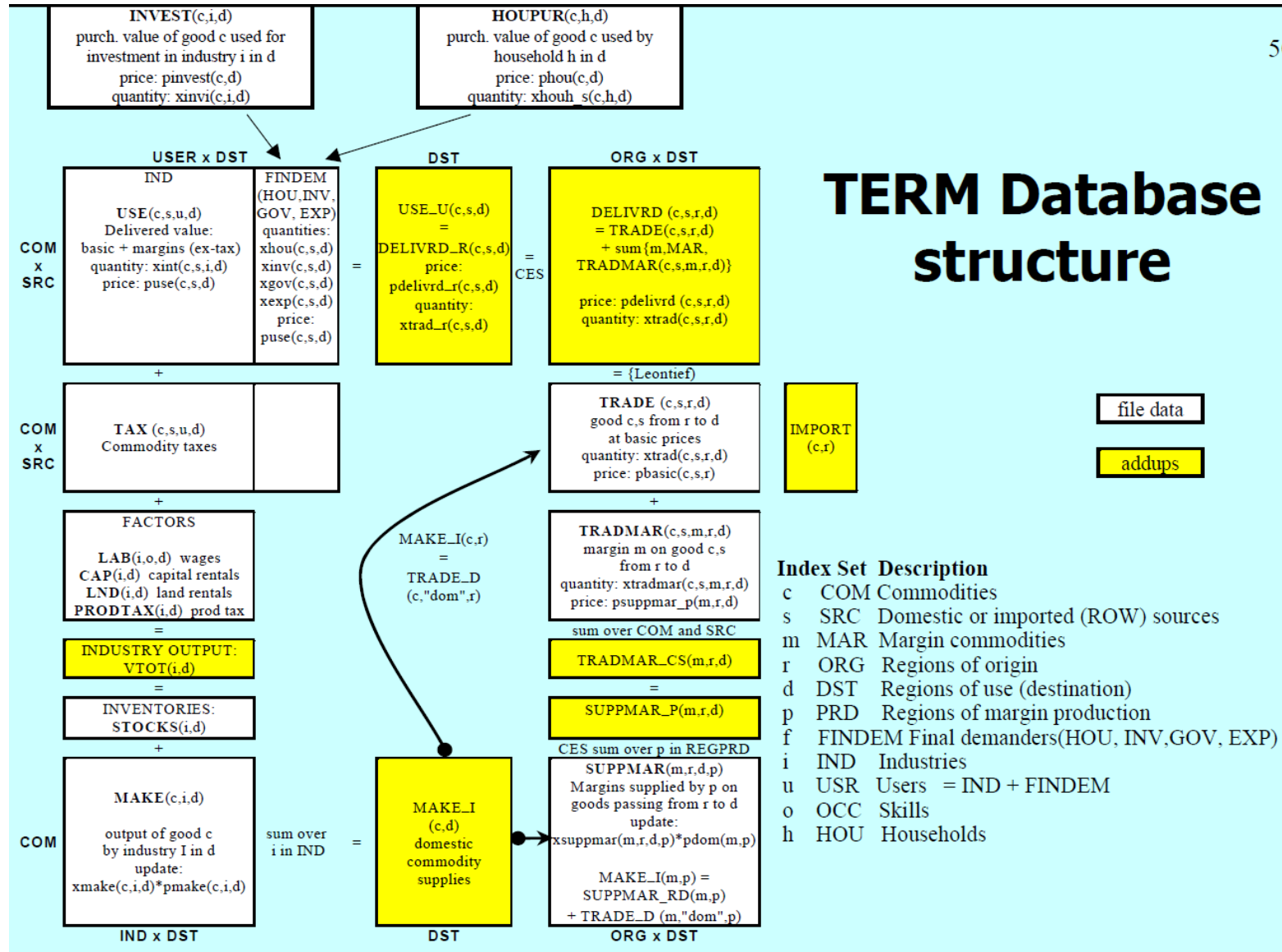- Snapshot of the Economy – Benchmark equilibrium

SAM requires Input-Output Table/Supply-Use Table, National Income Production Account, Labor Force Survey, Household Survey, etc.

- But even these are not enough to assemble a typical SAM!

- Economic Outlooks, Population projection, Industry Reports, etc.

# B. Structure of Social Accounting Matrix Database

| | Activity | Commodity | Labor | Capital | Household/ Firm | Govern- ment | Capital Account | ROW | Total |
|---|---|---|---|---|---|---|---|---|---|
| Activity | | Domestic Supply | | | | | | Exports | |
| Commodity | Intermed. Demand | | | | *Hous. Consump.* | Govt. Expend. | Investment | | |
| Labor | *Employee's Compen.* | | | | | | | Factor Inc. (Labor) | |
| Capital | Operating Surplus | | | | | | | Factor Inc. (Capital) | |
| Household/ Firm | | | Comp. Employees | Operating Surplus | Trans to Hou/Ent. | Trans. to Hou/Ent. | | Trans to Hou. | |
| Govern- ment | Indirect Tax (Net) | Import Tax | | | Income Tax/Corp. Tax | | | Trans. to Gov | |
| Capital Account | *Deprec.* | | | | Priv. Sav. | Gov. Sav. | | ROW Sav. | |
| ROW | | Imports | Factor Pay (Labor) | Factor Pay (Enter.) | Trans. to ROW | Trans. to ROW | | | |
| Total | | | | | | | | | |

# C. Structure of ORANI Database (National DB)

| | | Absorption Matrix | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 |
| | | Production | Invest | Household | Export | Government | Inventory |
| | | ← I → | ← I → | ← 1 → | ← 1 → | ← 1 → | ← 1 → |
| Basic Price | C×S | V1BAS | V2BAS | V3BAS | V4BAS | V5BAS | V6BAS |
| Taxes | C×S | V1TAX | V2TAX | V3TAX | V4TAX | V5TAX | Invent. Tax |
| Labour | O | V1LAB | | | | | |
| Capital | 1 | V1CAP | | | | | |
| ProdTax | 1 | V1PTX | | | | | |
| OthCost | 1 | V1OCT | | | | | |

C = Commodity
I = Industry
S = Dom/Imp
O = Labour type, Skilled/Unskilled

- V2TAX = 0
- V4TAX = V5TAX = 0.

# Present: TERM Database Structure

**TERM Database structure**

**INVEST(c,i,d)**
purch. value of good c used for
investment in industry i in d
price: pinvest(c,d)
quantity: xinvi(c,i,d)

**HOUPUR(c,h,d)**
purch. value of good c used by
household h in d
price: phou(c,d)
quantity: xhouh_s(c,h,d)

**USER x DST**

| IND | FINDEM (HOU,INV, GOV, EXP) |
|---|---|
| **USE(c,s,u,d)** Delivered value: basic + margins (ex-tax) quantity: xint(c,s,i,d) price: puse(c,s,d) | quantities: xhou(c,s,d) xinv(c,s,d) xgov(c,s,d) xexp(c,s,d) price: puse(c,s,d) |

**DST**

**USE_U(c,s,d)** = DELIVRD_R(c,s,d) price: pdelivrd_r(c,s,d) quantity: xtrad_r(c,s,d)

= CES

**ORG x DST**

**DELIVRD (c,s,r,d)** = TRADE(c,s,r,d) + sum{m,MAR, TRADMAR(c,s,m,r,d)} price: pdelivrd (c,s,r,d) quantity: xtrad(c,s,r,d)

| COM x SRC | **TAX (c,s,u,d)** Commodity taxes | |
|---|---|---|

= {Leontief}

**TRADE (c,s,r,d)** good c,s from r to d at basic prices quantity: xtrad(c,s,r,d) price: pbasic(c,s,r)

**IMPORT (c,r)**

file data

addups

**FACTORS**

**LAB(i,o,d)** wages
**CAP(i,d)** capital rentals
**LND(i,d)** land rentals
**PRODTAX(i,d)** prod tax

=

**INDUSTRY OUTPUT: VTOT(i,d)**

=

**INVENTORIES: STOCKS(i,d)**

+

MAKE_I(c,r) = TRADE_D (c,"dom",r)

**TRADMAR(c,s,m,r,d)** margin m on good c,s from r to d quantity: xtradmar(c,s,m,r,d) price: psuppmar_p(m,r,d)

sum over COM and SRC

**TRADMAR_CS(m,r,d)**

=

**SUPPMAR_P(m,r,d)**

CES sum over p in REGPRD

**MAKE(c,i,d)**

output of good c by industry I in d update: xmake(c,i,d)*pmake(c,i,d)

sum over i in IND =

**MAKE_I (c,d)** domestic commodity supplies

**SUPPMAR(m,r,d,p)** Margins supplied by p on goods passing from r to d update: xsuppmar(m,r,d,p)*pdom(m,p)

MAKE_I(m,p) = SUPPMAR_RD(m,p) + TRADE_D (m,"dom",p)

**IND x DST**          **DST**          **ORG x DST**

**Index Set  Description**
c    COM Commodities
s    SRC   Domestic or imported (ROW) sources
m   MAR  Margin commodities
r    ORG   Regions of origin
d    DST    Regions of use (destination)
p    PRD    Regions of margin production
f    FINDEM Final demanders(HOU, INV,GOV, EXP)
i    IND    Industries
u    USR   Users   = IND + FINDEM
o    OCC   Skills
h    HOU   Households

# Naming Convention for TERM DB

## The TERM Naming System    or GLOSS

**COEFFICIENT**

**variable**

**Name Part**

| | |
|---|---|
| cap | capital |
| lab | labour |
| lnd | land |
| prim | all primary factors |

| | |
|---|---|
| mar | margins |
| tax | indirect taxes |
| pur | at purchasers' prices |
| imp | imports (duty paid) |
| tot | total inputs for a user |

**Prefix**

none for
levels flow

p  % price

x  % quantity

del  ord.change

$LAB(i,o,d)$

$plab\_o(i,d)$

$xlab\_id(o)$

**Subscripts**

| | |
|---|---|
| c | COMmodities |
| s | SouRCe (dom/imp) |
| i | INDustries |
| m | MARgin |
| o | OCCupation |
| d,r,p | Region |

**Underscore** means
"adding up over"

# TERM-KOR Database Compiling Process

```
Base-year National          →          National (Single Region)
Input-Output Table (BOK)               ORANI-CGE Database
                                              ↓
Supplementary Data for      →          National (Single Region)
Sectoral Disaggregation                Dis-/Aggregated ORANI-
                                       CGE Database
                                              ↓
Regional Input-Output       →          Initial TERM-KOR Database
Table (BOK)                            (33 Sec., 17 Reg.)
                                              ↓
Recent National Income      →          Updated TERM-KOR
Account Data (BOK)                     Database
                                       (33 Sec., 17 Reg.)
                                              ↓
Zero Shock Simulation       →          Final Aggregated
                                       TERM-KOR Database
                                       (16 Sec., 17 Reg.)
```

# Present: Structure of ORANI Database (Multi-Regional DB)

|  | 차원 | 1 중간 투입 I | 2 고정 투자 I | 3 민간 소비 H | 4 수출 1 | 5 정부 소비 1 | 6 재고 변화 1 |
|---|---|---|---|---|---|---|---|
| BASD (기초가격) | C×S× | 1,597.0 | 378.6 | 601.8 | 695.2 | 250.1 | 5.9 |
| BASM (기초가격) | R | 442.5 | 55.3 | 68.8 | 2.1 | 0.0 | 0.7 |
| MARD (국내마진) | C×S× | 86.4 | 10.3 | 70.7 | 19.7 | 0.0 | 0.0 |
| MARM (수입마진) | M×R | 24.0 | 1.4 | 8.3 | 0.1 | 0.0 | 0.0 |
| TAXD (국내세) | C×S× | 35.4 | 33.0 | 47.8 | 0.0 | 0.0 | 0.3 |
| TAXM (수입세) | R | 10.7 | 2.3 | 7.4 | 0.0 | 0.0 | 0.1 |
| 1LAB (피용자보수) | 1×R | 750.2 |  |  |  |  |  |
| 1CAP (영업잉여) | 1×R | 751.1 |  |  |  |  |  |
| 1OCT (기타 생산비) | 1×I | 19.6 |  |  |  |  |  |
| 합계 |  | 3,717.0 | 481.0 | 804.8 | 717.0 | 250.1 | 8.6 |

Note: $C$=commodity, $I$=industry, $S$=source, $R$=region, $H$=households, $M$=margin.

# Application: Effects of COVID-19 (Regional Macro)

| 지역 구분 | 1 실질 민간소비 | 2 실질 투자 | 3 실질 수출 | 4 실질 수입 | 5 실질 GDP | 6 총고용 | 7 소비자물가 |
|---|---|---|---|---|---|---|---|
| 1 서울 | −0.68 | −0.69 | 0.20 | −0.15 | −0.10 | −0.61 | 0.04 |
| 2 인천 | −0.18 | −0.11 | 0.04 | −0.12 | −0.04 | −0.16 | 0 |
| 3 경기 | −0.94 | −1.29 | 0.21 | −0.77 | −0.25 | −0.84 | −0.01 |
| 4 대전 | −0.07 | −0.07 | 0.02 | −0.04 | −0.01 | −0.07 | 0 |
| 5 세종 | −0.01 | −0.02 | 0.01 | −0.01 | 0 | −0.02 | 0 |
| 6 충북 | −0.09 | −0.08 | 0.03 | −0.11 | −0.02 | −0.12 | 0 |
| 7 충남 | −0.16 | −0.19 | 0.05 | −0.36 | −0.11 | −0.25 | −0.01 |
| 8 광주 | −0.08 | −0.05 | 0.03 | −0.06 | −0.01 | −0.07 | 0 |
| 9 전북 | −0.13 | −0.08 | 0.04 | −0.06 | −0.02 | −0.09 | 0 |
| 10 전남 | −0.11 | −0.11 | 0.06 | −0.23 | −0.10 | −0.16 | 0 |
| 11 대구 | −0.13 | −0.10 | 0.04 | −0.04 | −0.02 | −0.09 | 0 |
| 12 경북 | −0.16 | −0.19 | 0.06 | −0.29 | −0.08 | −0.25 | 0 |
| 13 부산 | −0.22 | −0.12 | 0.06 | −0.08 | −0.03 | −0.15 | 0 |
| 14 울산 | −0.11 | −0.10 | 0.02 | −0.43 | −0.17 | −0.22 | −0.01 |
| 15 경남 | −0.24 | −0.22 | 0.07 | −0.23 | −0.05 | −0.22 | −0.01 |
| 16 강원 | −0.07 | −0.07 | 0.05 | −0.01 | −0.01 | −0.06 | 0 |
| 17 제주 | −0.03 | −0.03 | 0.02 | 0 | 0 | −0.02 | 0 |

# Application: Effects of COVID-19 (Regional Effects)

(a) real GDP
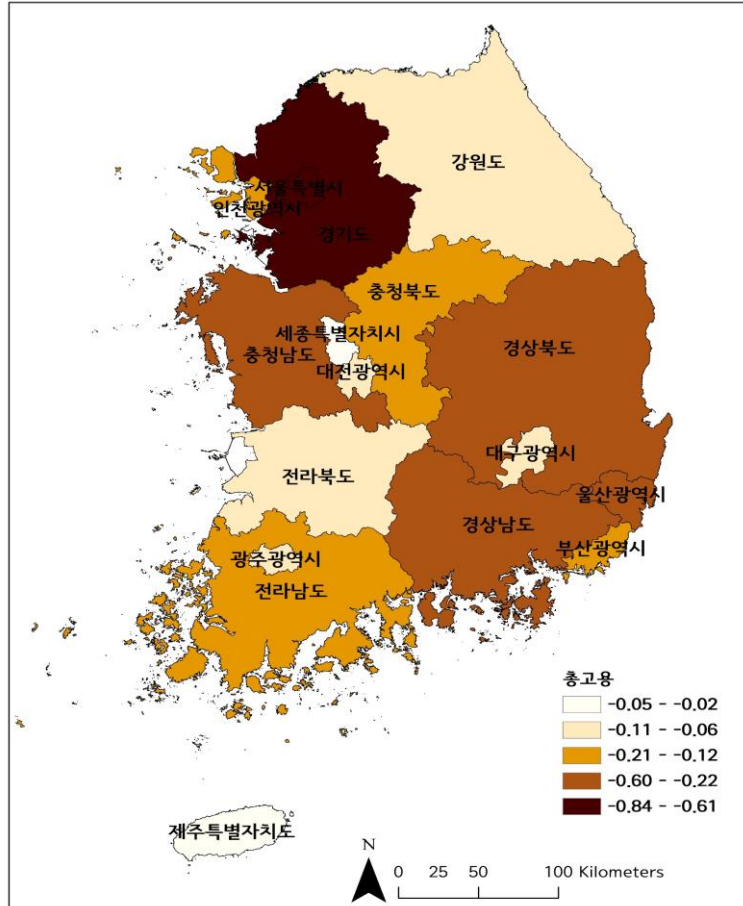
(b) Employment
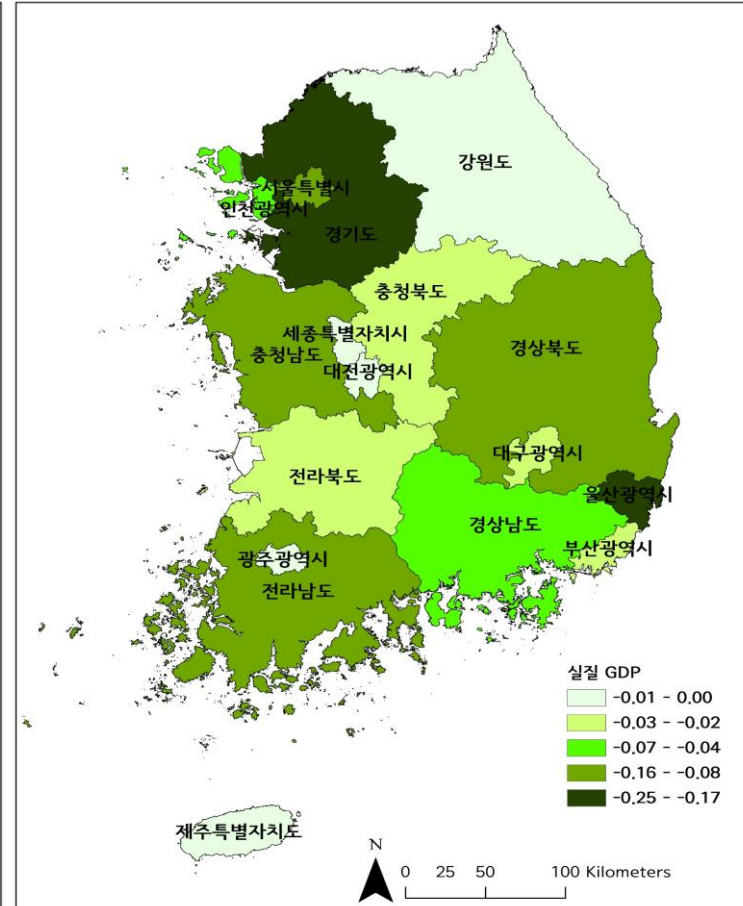
( c) real Consumption
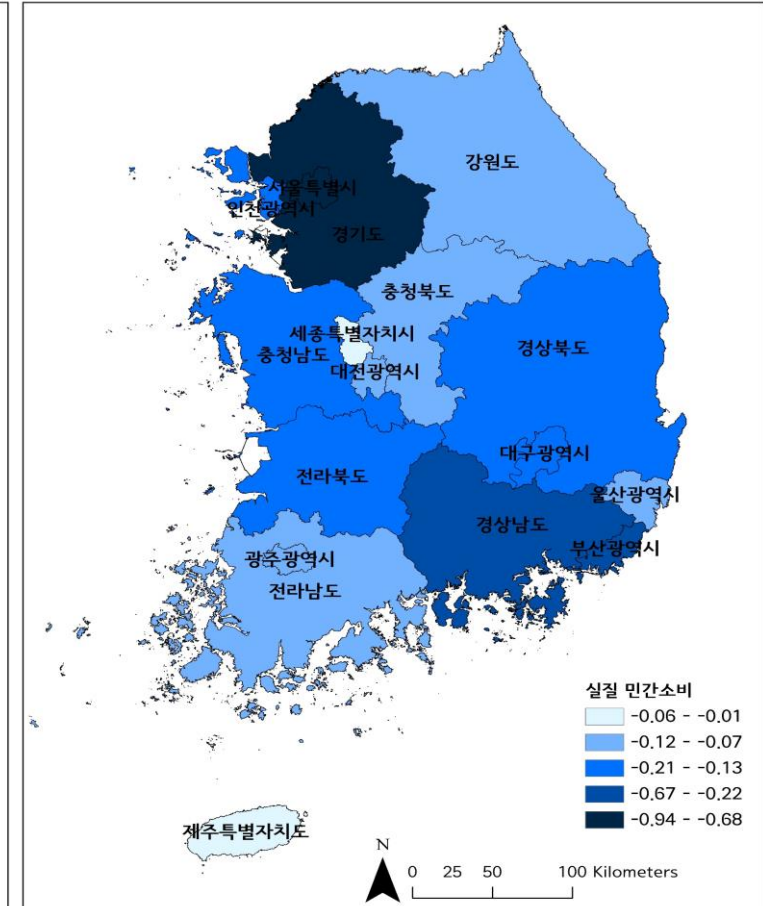
# CGE + Micro-Simulation: How to?

In order to analyze regional growth-employment-prices-consumptions, current Regional CGE Model (aka TERM-KOR) is good enough

- But for the policy issues such as income distribution, Poverty, and Polarization, reinforcing household heterogeneity is essential

A natural solution to this direction is to combine regional CGE model and Micro-simulation modeling technique

- Adapt some ideas/tools from Statistics Canada (for example, SPSD/M etc.)
- But we need huge computing power!

# Development of the Canadian MS model
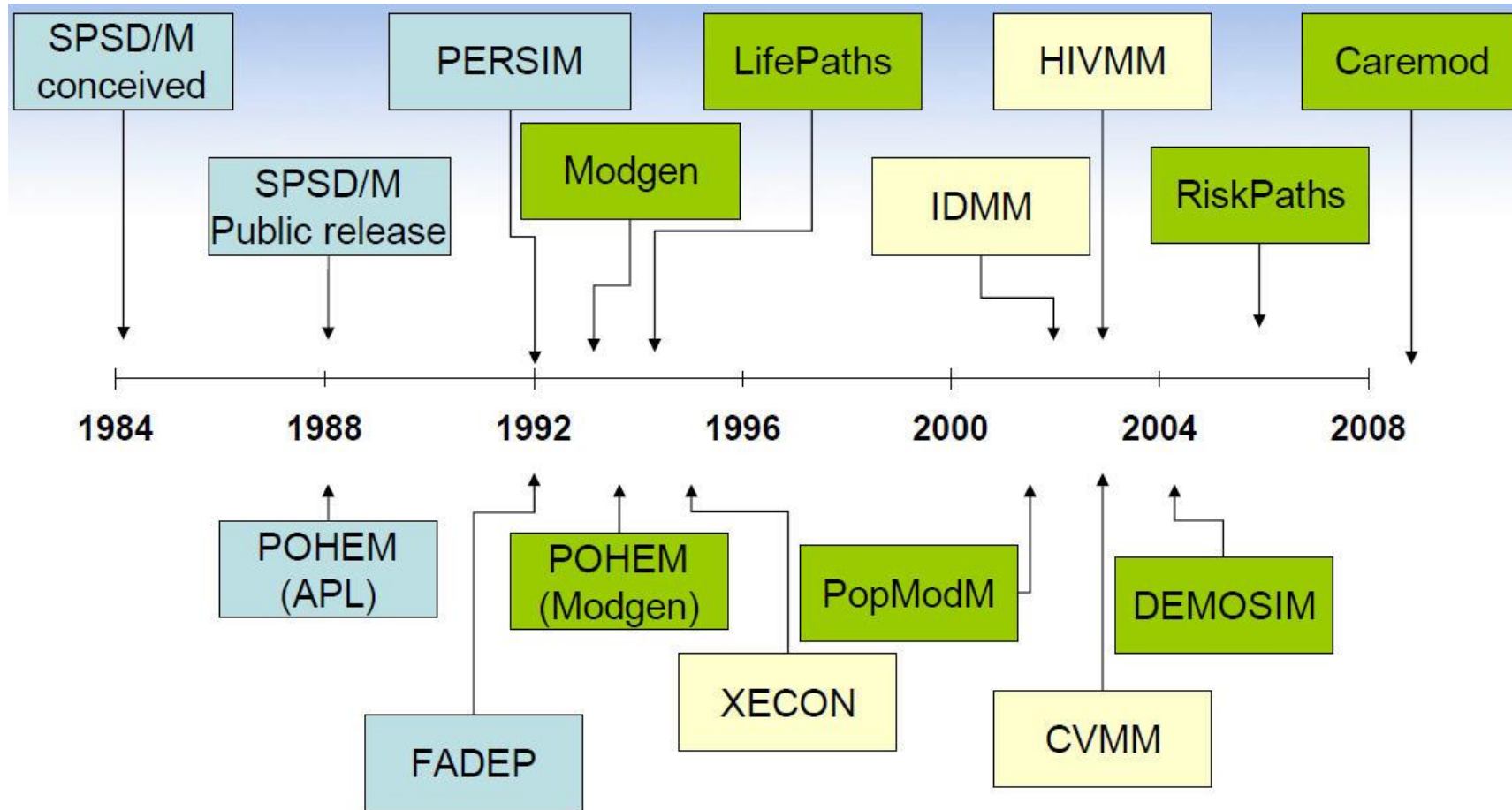


source: Spielauer, M. (2012), "Microsimulation and Public Policy: Issues and Prospects." http://www.spielauer.ca/Auckland_MS.pdf

# Future: Types of Cloud Services
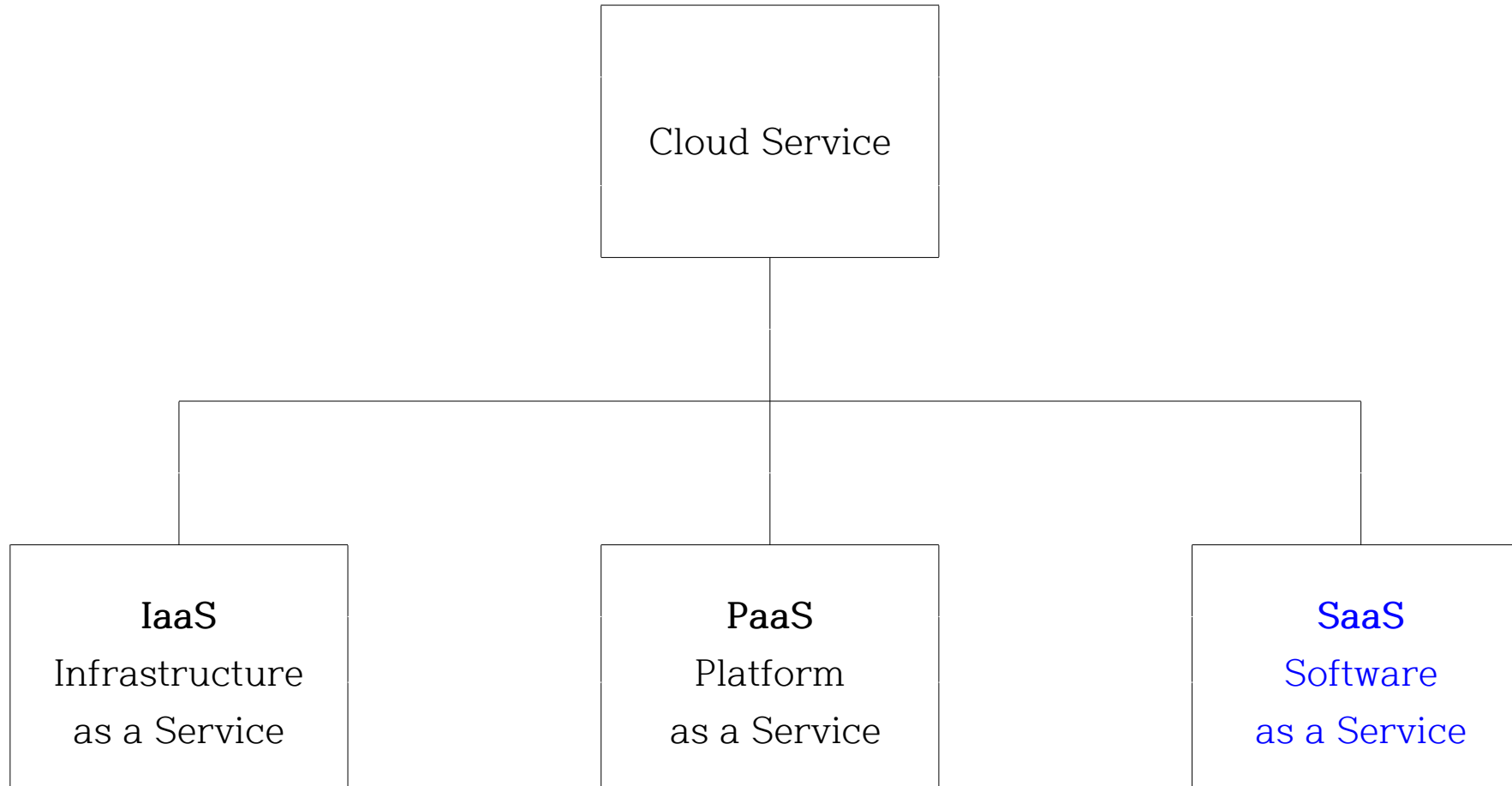
# Comparison of Cloud Services

| On-site | IaaS | PaaS | SaaS |
|---------|------|------|------|
| Applications | Applications | Applications | Applications |
| Data | Data | Data | Data |
| Runtime | Runtime | Runtime | Runtime |
| Middleware | Middleware | Middleware | Middleware |
| O/S | O/S | O/S | O/S |
| Virtualization | Virtualization | Virtualization | Virtualization |
| Servers | Servers | Servers | Servers |
| Storage | Storage | Storage | Storage |
| Networking | Networking | Networking | Networking |

■ You manage
■ Service provider manages

# Cloud Market Trend

'Escape from 'on-premise' 개별 기업이 각각 서버를 구축하고 유지 및 관리할 필요가 없게 됨

Cloud 서비스에서는 서버 관리가 불필요 (업체에서 다 해주므로),  기본적으로 유선통신이므로 (해저 광케이블 이용) 거리에 따른 품질의 차이가 있음

*   소규모 start-up 기업이나 글로벌 기업 (가령, Netflix)에 적합

금년도 전세계 Cloud 시장 규모는 3,069억 달러 (350조 원), 그 중 약 1/3은 Cloud 구축에 사용

*   해외: Amazon AWS (32%), MS Azure (19%), Google GCP (7%), Alibaba (6%), 그 외 (37%). Big 3사가 전 세계의 60%를 차지하고 있음

*   국내: LG CNS, KT Cloud, Gabia Cloud, Kakao i-Cloud, etc.

*   2021년을 기준으로 국내 cloud 시장 점유율은 AWS 58.1%, GCP 14.2%, Naver 9.4%, Azure 5.5%, KT 2.2%, Oracle 2.1%, etc.

# Quantum Computing?

Combining CGE Modeling + Micro-Simulation requires huge resources

- One possible solution is the quantum computing
- But there are lots of uncertainty in the future of quantum computing

Need to find more realistic alternative

- Amazon EC2 or MS Azure?
- What else?

# Summary

South Korea is the 16th country that uses Regional (IRIO) CGE Model

- TERM-KOR CGE model has 33 sectors and 17 regions for the South Korean economy
- 229 Sub-region classification in Top-Down manner, and thus can be used for detailed analysis for regional income distribution

The only limit is the availability of administrative data on small-area income level

- One possible area of applying CGE+MS is the safety income experiment of the City of Seoul
- The experiment is currently undergoing

# Summary

Lots of other things can be done with Regional CGE model with Micro-simulation

- Bottom-Up Regional CGE Model for 17 Metro/Do region is ready to use for the evaluation of public investment projects (such as the construction of new airport in Pusan)
- 229 Sub-SiGunGu province modeling is possible in a Top-Down manner

One possible way of extending applicability of TERM-KOR model is to use Administrative data for households/individuals for welfare policy

- This will be especially powerful in decreasing poverty and increasing policy effectiveness by targeting specific area for income support
- traditional tax-benefit analysis will benefit the most

# Schematic Pedigree of the TERM-KOR Model

# 윤수호 박사의 지식 나눔

"공학연구자들이 스스로를 지키는 선명한 기준"

- 재현 가능한가?

- 기본 과학원리를 따르는가?

- 기존 기술보다 나은가?

- 논리 언어(자연언어, 수학)로 설명이 가능한가?

- 관계 언어(통계)로 검정하였는가?

- 역사적 맥락이 있는가?

- 치명(致命)적 요소는 없는가?

- 審美的인가?

"Art is a lie that makes us realize the truth." - Pablo Picasso