TALL SOM FORTELLER

SNOW – en anvendt generell likevektsmodell i modellporteføljen

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Statistisk sentralbyrå
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Outline

- The SNOW family (SNOW-NO, SNOW-GLO, SNOW-DYN)
- What are and why do have CGE (Computable General Equilibrium) models?
- A. SNOW-NO (Norway)
  - The modules
  - Making projections
  - Analysis of tax reforms
  - Analysis of energy and climate policies
- B. SNOW-GLO (Global)
- C. SNOW-DYN (Norway – Dynamic)
  - Incl. endogenous labor supply

The SNOW* family members

SNOW-FAMILY

* **S**tatistics **NO**rway's **W**orld models

A) SNOW-NO: Fit for macroeconomic, emissions and climate policy – projections and analysis
- focus on Norway as a small, open economy
- rest of the world exogenously treated (not affected by Norwegian trends or policies)

Static:
- calibrated to a base year (currently 2013) (can be forwarded)

Recursive-dynamic:
- calibrating a baseline ahead
- give growth in resources, productivity, international prices
- capital accumulation links periods:

$$K = (1-\delta)(K_{-1} + I_{-1})$$

B) SNOW-GLO: Fit for international policy decisions, carbon leakage and scenario building
- a global version – every country/region endogenous and linked through trade

C) SNOW-DYN: (will be) fit for various studies of tax policies, tax interaction and welfare implications
- forward-looking
- intertemporal
- endogenous labor supply (also applies to newest SNOW-NO)

Why do we use CGE models?

a) General – calibrated to NA, all markets are in equlibrium

b) Disaggregated – many sectors and goods

c) Longterm – trends, no cycles

d) Focus on social costs and welfare: equivalent variation/total discounted utility
    a) Reallocation of resources give gains/losses

SNOW-NO ≈ MSG

New programming language/platform – GAMS/MPSGE

- Less vulnerable
  - Many users with high competence (recruitment/training)
  - Many technical tips and solutions online
  - Compact coding – few typos

- Better and more effective research
  - Low investment costs
  - Excel-based
  - Replicable results improve confidence
  - Easy to redesign model to new research questions and data:

    Flexible aggregation and calibration

… not at the expense of analytical capacity

- SNOW can copy MSG, if desired

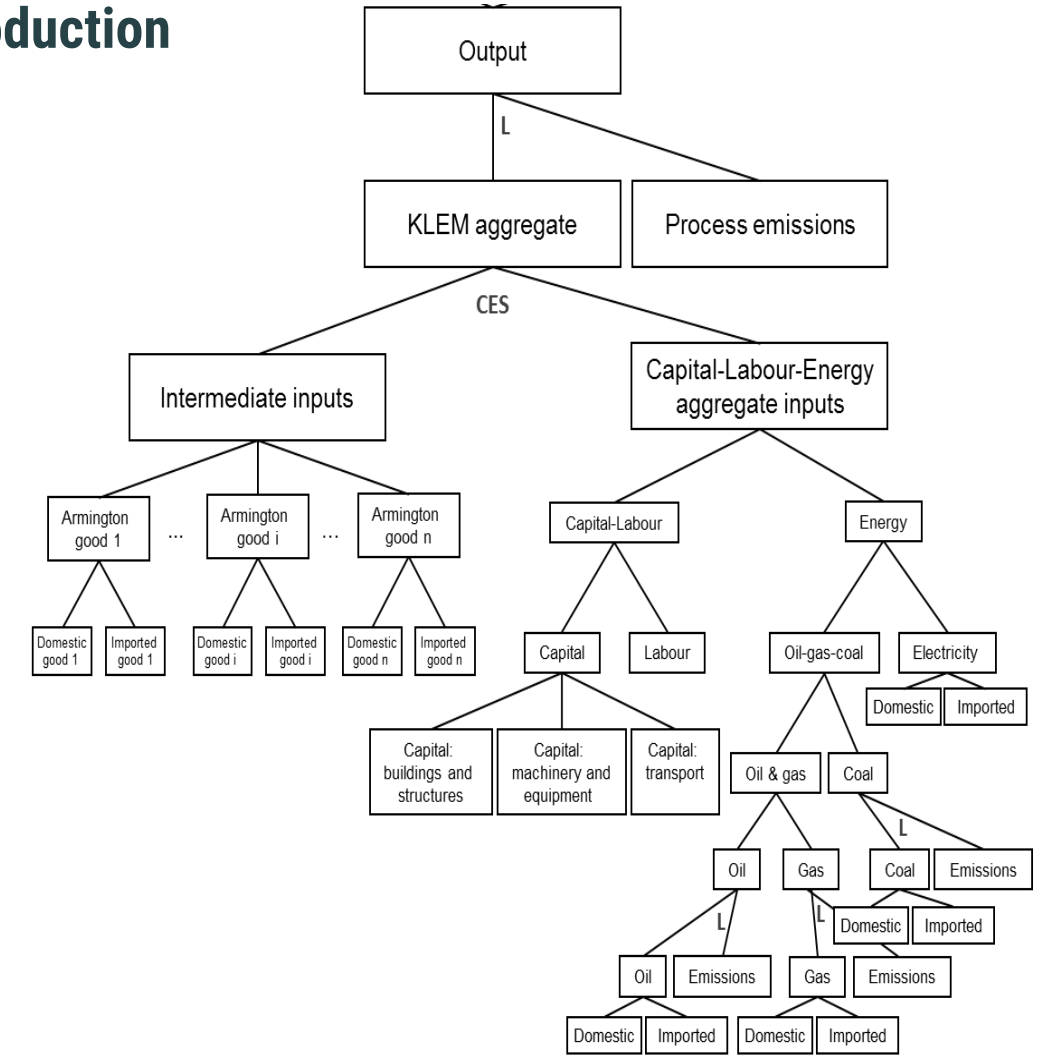
Firms and production sectors

- 46 production sectors - disaggregated
- Representative firm of each sector maximizes the profit by employing factors of production (labor, capital, resource) and intermediate input for each period
- CES (Constant elasticity of substitution) nesting structure
- Output can be sent to domestic market or export market (Constant Elasticity of Transformation)
- Various taxes are implemented for each product
  - Taxes/subsidies on product (same as household goods)
  - Wage tax by employer
  - Taxes on production including ETS (emission trading system) quota payment
- Income tax for labor income and capital income

46 production sectors:

1	Agriculture	24	Transport equipment nec
2	Forestry	25	Machinery and equipment, incl. electronic equipment
3	Fishing	26	Manufactures nec
4	Coal	27	Electricity
5	Crude oil & gas	28	Gas manufacture & distribution
6	Minerals nec	29	Water
7	Food products – meat	30	Construction
8	Vegetable oils and fats	31	Trade
9	Dairy products	32	Transport nec
10	Food products nec	33	Water transport
11	Beverages and tobacco products	34	Air transport
12	Textiles	35	Communication
13	Wearing apparel	36	Financial services nec
14	Leather products	37	Insurance
15	Wood products	38	Business services nec
16	Paper products, publishing	39	Recreational and other services
17	Petroleum and coal products	40	Defence
18	Chemical, rubber, plastic products	41	Dwellings
19	Mineral products nec	42	Public Administration (Central): Education, Health, etc.
20	Ferrous metals	43	Public Administration (Local): Education, Health, etc.
21	Metals nec	44	Private education, health, etc.
22	Metal products	45	Waste (public)
23	Motor vehicles and parts	46	Waste (private)

Nesting structure of production



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Labor

- Perfectly mobile among production sectors
- Two versions:
  - Exogenous labor supply, no effects of taxation, or
  - Endogenous labor supply - time endowment can be used for either labor or leisure.
- Leisure and elasticity of substitution between material consumption and leisure are calculated such that they are consistent with given labor supply elasticities.
  - Uncompensated labor supply elasticity from LOTTE-Arbeid: 0.2
  - Compensated labor supply elasticity from Chetty (2012 Econometrica): 0.5
- Calculated leisure share out of total time is 38%.

Households:

- One representative household earns net income from all factors/endowments (labour, capital, natural resources)
- CES (Constant Elasticitiy of Substitution) utility function, Aggregate consumption consists of 22 household commodities

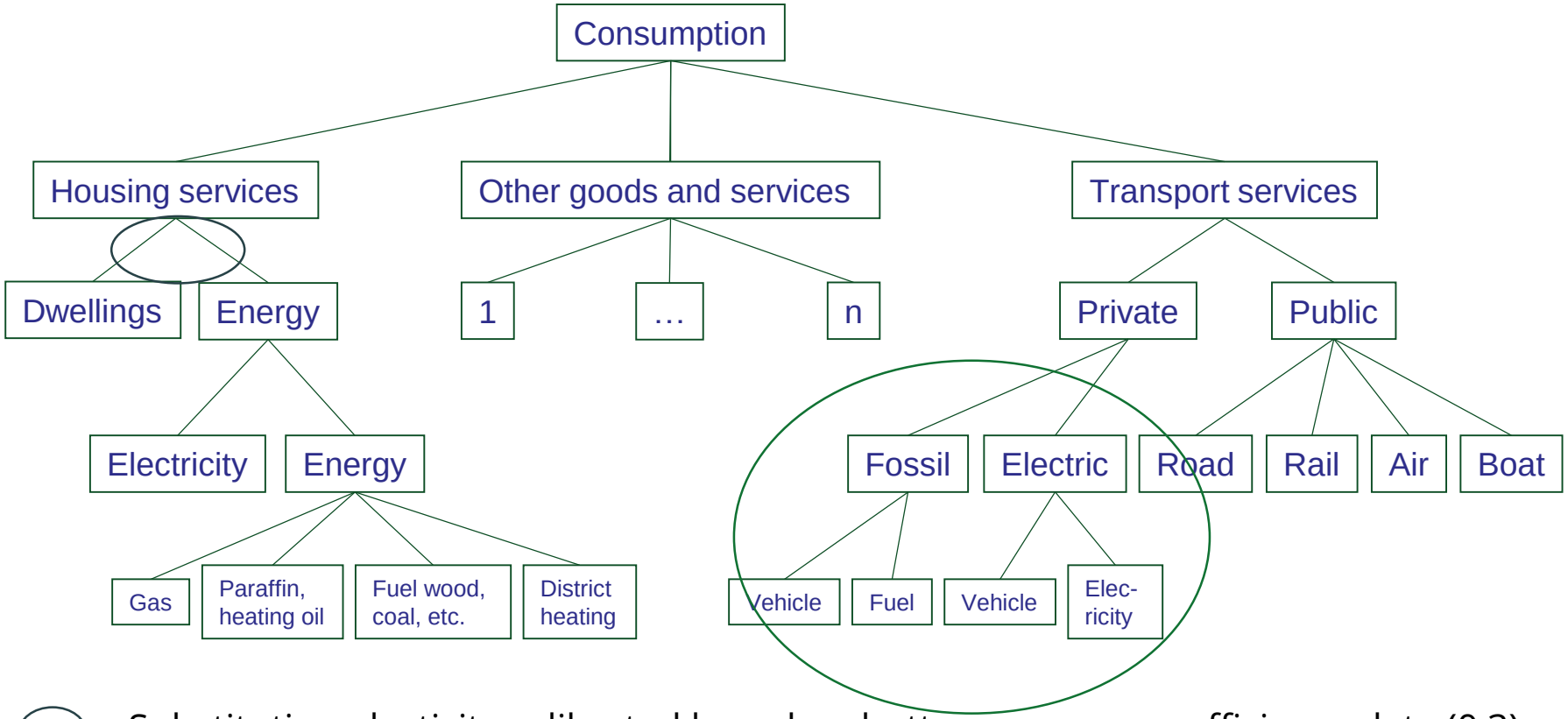
- Various taxes are implemented for each household commodity
  - electricity tax
  - fuel tax
  - CO_2 tax
  - VAT and other taxes/subsidies on product

- **Static/recursive model**: Maximises utility in each period for given income and substitutability among goods, savings (and labour supply).

- **Intertemporal model:** (Ramsey type) Maximizes discounted utility consisting o utility (consumption, leisure) of all periods (current time period is 5 years), given the budget constraint (capital and labor income) and substitutability of goods and leisure

A-SNOW-NO

Nesting structure of consumption (CES)



Substitution elasticity calibrated based on bottom-up energy efficiency data (0,3)

Private transport substitution can be calibrated based on bottom-up data (2,0)

Public sector:

- Exogenous public consumption (GP)

  split into state and municipalities (GS, GK)

- They consume all products in fixed shares,

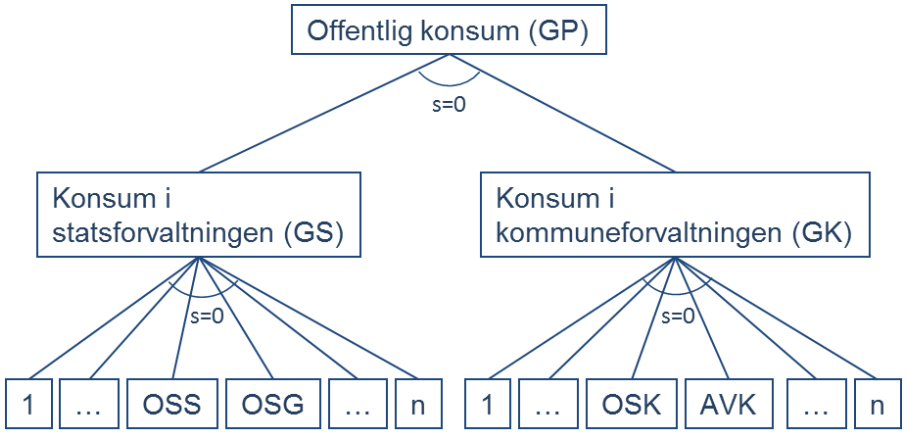
  mostly products from the public sectors

  (administration S,K, defence, waste management)

- Balanced public budget:

  GP + investments + transfers = tax income + SPU return

A. SNOW-NO



Trade:

- Balance of Payment vis-á-vis abroad (BoP) is exogenous in static/recursive model (its growth rate must be defined)
- BoP = net trade + other financial transfers, incl. SPU and EU-ETS purchases
- All goods have a domestic and a foreign variety with substitutability
  (Armington (CES) in imports, constant elasticity of transformation (CET) in export)
- International prices given - exchange rate adjusts

Making projections:

Adjusting exogenous parameters and variables to attain a consistent projection, e.g. based on historical trends, expert views or other models (e.g. DEMEC)

Sequences in FIN's Longterm Perspectives (PM) and National budget (NB) projections:

1. Determine the balance-of-payments-pathway
   - in and out of The Sovereign Wealth Fund (SPU)
   - Foreign prices
   - Development aid etc.

   → grBoP

2. Determine labour supply, public consumption (and employment)
   - gr og grG

3. Build a reasonable industrial composition, i.e.,
   use productivity and unit emissions assumptions, etc..
   to determine production, energy use and emissions in sectors

Analysis of tax reforms:

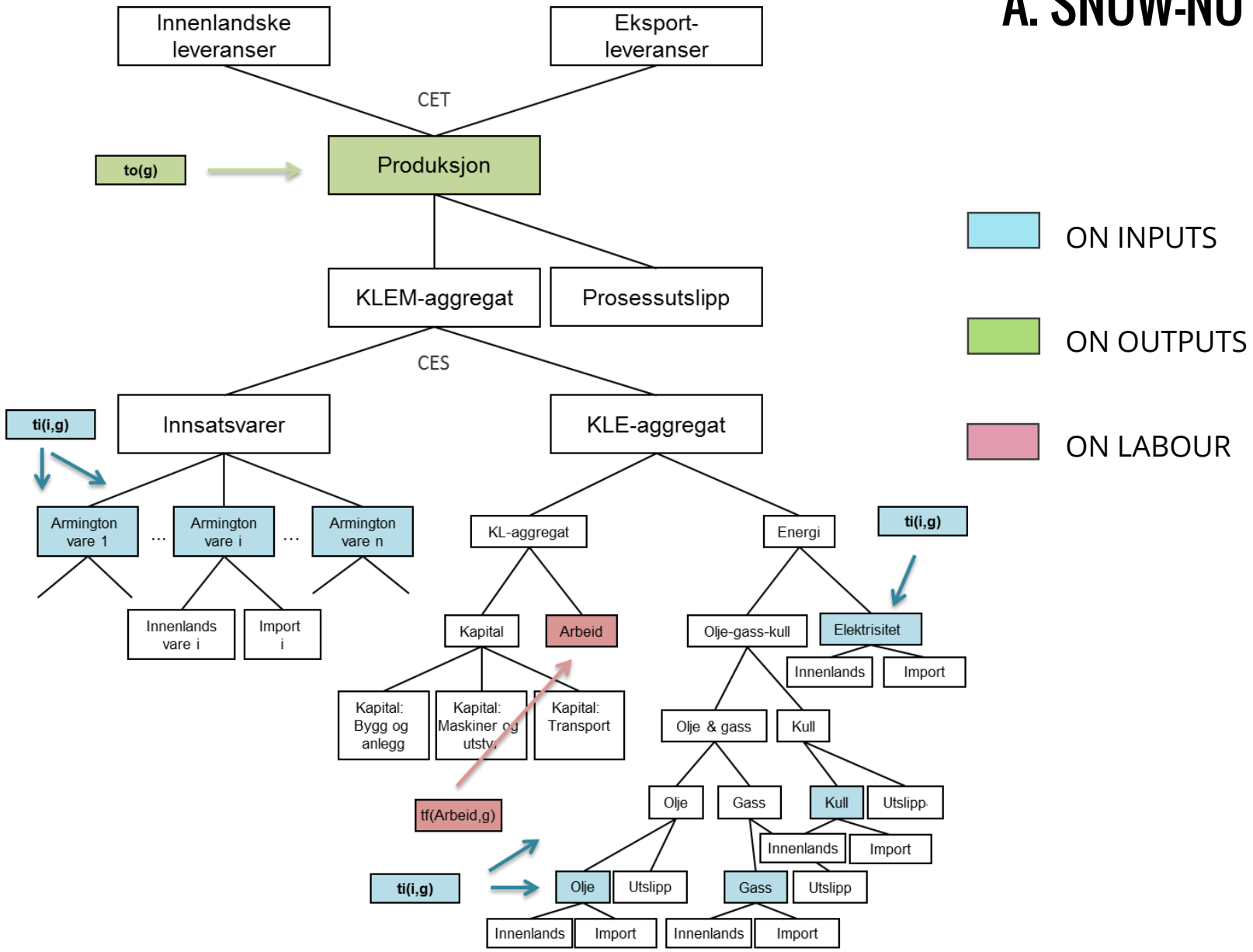
A. SNOW-NO

Taxes in the input-output table

Note:
I-O includes *values* of taxes; we calculate average rates by dividing by tax base values

Skatteart	Parameter	Inngår i:
Skatter/avgifter på innsatsfaktorer ti(i,g)		
• **Avgift på elektrisk kraft + energifondet** ○ **Avgift på elektrisk kraft** ○ **Avgift på elektrisk kraft til energifondet**	tEle('ELE', g)	ti('ELE', g)
• **Veibruksavgift på diesel og bensin**	tFuel('OIL', g)	ti('OIL', g)
• **CO_2-avgift på mineralske produkter**	tCO2('OIL', g)	tCO2('OIL', g)
• **Kvotekjøp på EU ETS (energiutslipp)**	ETSpay_en(i,g)	ETS_p_exo(g)
Skatter/avgifter på produksjon to(g)		
• **MVA**	tVAT(g)	to(g)
• **Naturressursskatt og eiendomsskatt på elektrisitetsproduksjon**	toRest(g)	to(g)
• **Engangsavgift på motorvogner (bare for husholdninger bare; inngår i investeringer for næringer)**	toRest(g)	to(g)
• **For petroleumsvirksomhet:** ○ **CO_2-avgift på mineralske produkter** ○ **Avgift på utslipp av CO_2 i petroleumsvirksomhet**	tCO2('OIL', 'CRU') tCO2CRUspec('CRU')	to('CRU')
• **Kvotekjøp på EU ETS (prosessutslipp)**	ETSpay_p(g)	ETS_p_exo(g)
• **Andre produkt- og næringsskatter og -avgifter**	toRest(g)	to(g)
Skatter/avgifter på arbeidskraft tf(f,g)		
• **Arbeidsgiveravgift til folketrygden**	tfL1('LAB',g)	tf('LAB',g)
• **Arbeidsgivers andre trygde- og pensjonspremier o.l.** ○ **Arbeidsgivers andre faktiske trygde- og pensjonspremier** ○ **Arbeidsgivers beregnede trygde- og pensjonspremier**	tfL2('LAB',g)	tf('LAB',g)

A. SNOW-NO


Innenlandske leveranser
Eksport-leveranser
CET
to(g)
Produksjon
KLEM-aggregat
Prosessutslipp
CES
ti(i,g)
Innsatsvarer
KLE-aggregat
Armington vare 1
Armington vare i
Armington vare n
Innenlands vare i
Import i
KL-aggregat
Energi
ti(i,g)
Kapital
Arbeid
Olje-gass-kull
Elektrisitet
Innenlands
Import
Kapital: Bygg og anlegg
Kapital: Maskiner og utstyr
Kapital: Transport
Olje & gass
Kull
Olje
Gass
Kull
Utslipp
tf(Arbeid,g)
Innenlands
Import
ti(i,g)
Olje
Utslipp
Gass
Utslipp
Innenlands
Import
Innenlands
Import
ON INPUTS
ON OUTPUTS
ON LABOUR

Analysis of tax reforms:

Other taxes (outside input-output structure)

Alminnelig inntektsskatt på arbeid og kapital

Belastes eierne av primærfaktorene kapital og arbeidskraft (husholdningene)

Effektiv skattesats er beregnet på grunnlag av skatteinntektene i 2013

$$= \frac{\text{Skatt inntekt kommune og fylke og Fellesskatt (mill.NOK)}}{\text{Alminnelig inntekt etter særfradrag (mill.NOK)}} = \frac{295\ 616}{1\ 242\ 964} = 0.24$$

Særskatt på petroleum

Ressursrentebeskatningen

Kalibrert basert på skatter og avgifter i 2013:

$$= \frac{\text{Betalte skatter og avgifter (mill.NOK)}}{\text{Verdien av ressursinnsats i petroleumsproduksjonen (mill.NOK)}} = \frac{206\ 436}{246\ 178} = 0.839$$

Climate policy

- Carbon pricing (Emissions trading system or carbon tax)
  - Revenue recycling
    - Lump-sum rebate to households
    - Labor tax cut
    - Capital tax cut
- Subsidy on technology (e.g., subsidy on electric vehicles or on renewable electricity technologies)
  - Financing of subsidy
    - Electricity demand tax
    - Electricity tax based on carbon content of electricity generation
    - Lump-sum tax, labor tax, capital tax

Tax policy

- Swap of distorting income tax with consumption taxes
  - In intertemporal models, capital tends to be more elastic than labor, and thus reducing capital tax may be more beneficial than reducing labor tax
- How to finance increasing expenditures of social welfare system?
  - Increase labor and/or capital taxation or “emission” taxes? Lower transfers?

International/cross-border topics:

SNOW-GLO:

- Similar structure as SNOW-NO
- Less details - e.g. only CO2
- Static, but currently recursive version developed
- Flexible sectoral and regional resolution

GTAP DATABASE:

- NAs and trade links for almost all regions/countries
- Recently updated to 2014 (release by summer)
- Norway as separat country
- Originally built for trade and global food production topics
- More emphasis on energy and emissions data

APPLICATIONS in SSB:

- Carbon leakage and instruments for limiting carbon leakage
- Impacts of international treaties and simultaneous changes in many parts of world (EU-ETS, Effortsharing regulation, Paris Agreement, Supply-side treaty)
- Scenarios for stresstesting Norwegian economy and policies

  ensure consistent changes in factors external to the Norwegian economy
- International model comparisons (Energy Modelling Forum)

SNOW-NO vs. SNOW-DYN

SNOW-NO

- Recursive dynamic model
- Myopic
- Households' optimization is done for each time period
  - Consumption vs. Saving (Investment)
  - Work or leisure

SNOW-DYN

- Intertemporal model (known as Ramsey model)
- Forward looking with perfect foresight
- Households' optimization is done for the whole time periods
  - Consumption vs. Saving (Investment)
  - Work or leisure

Investment decision and capital accumulation

In SNOW-NO (recursive-dynamic model):

- Households determine saving endogenously for each time period, and saving is equal to investment. This investment leads to new capital in next period.

In SNOW-DYN (intertemporal model):

- Households optimize saving (investment) decision over time with perfect-foresight given labor and capital income. Determines the consumption path

Investment and capital accumulation (cont.)

- Investments can be transformed into three types of capital :
  - Machinery and equipment
  - Buildings and construction
  - Transport equipment
- (Constant elasticity of transformation).

SNOW - KVARTS – FINDEPS modell

- Hva skal modellen brukes til?
  - Framskrivinger (økonomi/utslipp)
  - Politikkanalyser (skatteanalyser/miljøpolitikk)
- Hvilke effekter ønsker man å analysere?
  - Velferdseffekter
  - Allokering mellom næringer

1. Starte med problemstilling
2. Valg av modell
3. Trenger modellen å modifiseres/utvikles, evnt bedre kvantifisering?

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Takk!

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