Introduction to GTAP

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Basic features

It describes the world (global) economy

- consisting of regional economies (naming convention)
- each consisting of many producers
- each governed by a regional household taking decisions about the private and public cosumption and savings
- each economy has the same theorethical structure (but different size and parameters).

Basic features

- Standard GTAP assumptions:
  - perfect competition, constant returns to scale
  - static model, no intertemporal choice, no dynamics
  - international trade in differentiated products (Armington assumption)
- Non-standard features
  - Constant Differrence of Elasticities (CDE)
  - Transport sector
  - Global bank

Regional household

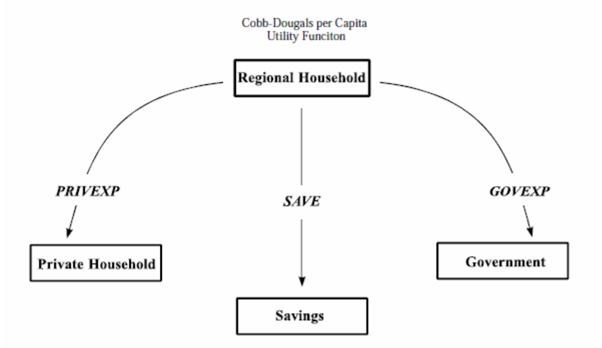
- ...is an entity that
  - owns the factors of production and can tax other entities (firms, activities)
  - decides on the consumption expenditure

RH: preferences

The regional household

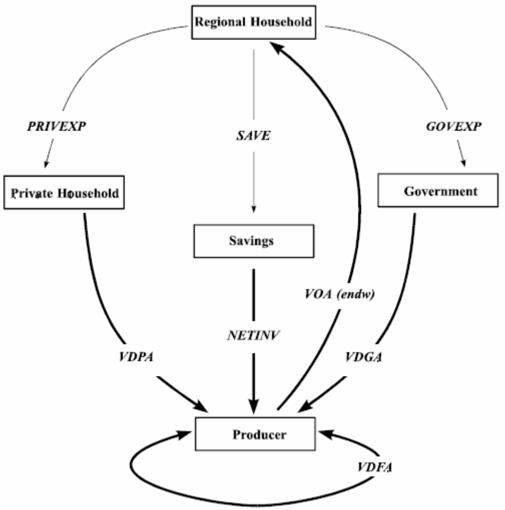
- Allocates expenditures on
  - private consumption (PRIVEXP)
  - public consumption (GOVEXP)
  - savings (SAVE)

RGD: Preferences



Source: Brockemeier, 2001, GTAP TP 8

Circular flow in the closed economy



Closed economy with taxes

RH can tax:

- Private consumption
- Public consumption
- Producers

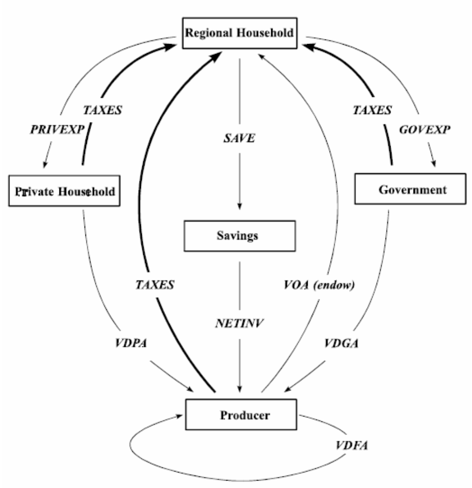
RH owns factors so taxes only distort prices
Tax revenues have nothing to do with govt consumption.

Market prices/Agent prices

Model is built along these lines

- Agents make transactions through markets
- Each transaction is actually two transactions *agent–market–agent*
- In transactions seller–market
  - agent's price is the seller price
  - market price is the seller price plus taxes
- In transactions market–buyer
  - agent's price is the buyer price
  - market price is the buyer price less taxes
- In an open economy there are also world prices

Closed economy with taxes

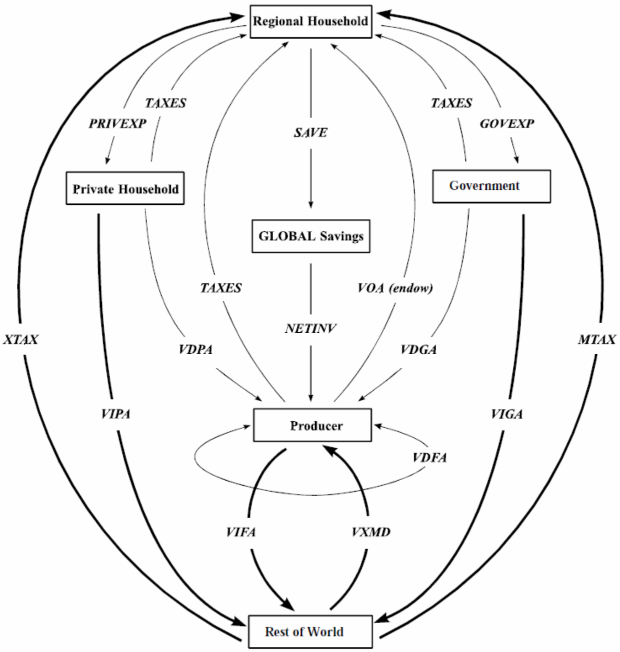


Source: Brockemeier, 2001, GTAP TP 8

Open economy

- In an open economy
  - Each agent imports and exports (np. VDPA i VIPA)
  - Entreprises export final and intermediate goods and import intermediate goods
  - RH taxes imports and exports
  - Savings go to the global banks
  - Global bank finances investment
  - Transport sector earns the difference between FOB and CIF price.

Źródło: Brockemeier (2001), GTAP TP 8



Sets

- Sets:
  - REG: POL, EU, ROW
  - TRAD_COMM (dobra handlowe: np. food, mnfcs, svcs)
  - MARG_COMM (svces)
  - NMRG_COMM (food, mfcs)
  - ENDW_COMM (land, unsklab, sklab, capital, NatRes)
  - ENDWS_COMM (land, NatRes)
  - CGDS_COMM (cgds)
  - PROD_COMM

GTAP.TAB

```
|-------------------------------------|
|         DEMD_COMM                   |
|-----------------------------------------------------|
| ENDW_COMM |        TRAD_COMM        |   CGDS_COMM   |
|-----------------------------------------------------|
|        NSAV_COMM                                    |
|-----------------------------------------------------|
            |                    PROD_COMM            |
            |-----------------------------------------|

|-------------------------|
| ENDW_COMM               |
|-------------------------|
| ENDWM_COMM | ENDWS_COMM |
|-------------------------|
Source: GTAP.TAB, wersja 6.2
```

Model equations

- Can be grouped into
  - Accounting relations
  - Price equations
  - Market clearing equations
  - Zero profit equations

Distribution of output

- Value of output in agents price equals the value of output at market price:
  $VOA(i,r) + PTAX(i,r) = VOM(i,r)$
- VOM is equal to sales in the domestic and foreign markets and the use by the transport sector
  $VOM(i,r) = VDM(i,r) + VST(i,r) + \sum_s VXMD(i,r,s)$
- The world price contains the export tax/subsidy
  $VXMD(i,r,s) + XTAXD(i,r,s) = VXWD(i,r,s)$
- Import price includes the transport costs
  $VXWD(i,r,s) + VTWR(i,r,s) = VIWS(i,r,s)$
- The market price of the import good includes the tariff
  $VIWS(i,r,s) + MTAX(i,r,s) = VIMS(i,r,s)$
- All the uses of imports are equal to total imports
  $\sum_r VIMS(i,r,s) = VIM(i,s) = VIPM(i,s) + VIGM(i,s) + \sum_j VIFM(i,j,s)$

Linearization

Equation $VOM(i,r) = VDM(i,r) + VST(i,r) + \sum_s VXMD(i,r,s)$ can be rewritten:

$$PM(i,r) \cdot QO(i,r) = PM(i,r) \left[QDS(i,r) + QST(i,r) + \sum_s QXS(i,r,s) \right]$$

Divide by $PM(i,r)$:

$$QO(i,r) = QDS(i,r) + QST(i,r) + \sum_s QXS(i,r,s)$$

Linearizng:
$qo(i,r) \cdot QO(i,r) =$
$qds(i,r) \cdot QDS(i,r) + qst(i,r) \cdot QST(i,r) + \sum_s qxs(i,r,s) \cdot QXS(i,r,s)$,
where $qo(i,r) = \frac{dQO(i,r)}{QO(i,r)}$ and same for other quantities..

Demand

Regional household

- Private consumption expenditures
  $VPA(i,s) = VDPM(i,s) + DPTAX(i,s) + VIPA(i,S) + IPTAX(i,s) = VDPM(i,s) + VIPM(i,s)$

Govt:

- Govt expenditures
  $VGA(i,s) = VDGM(i,s) + DGTAX(i,s) + VIGA(i,S) + IGTAX(i,s) = VDGM(i,s) + VIGM(i,s)$

Firms

VFA - value of firms purchases at agent's prices:

- For $i \in TRAD\_COMM$:
  $VFA(i,j,s) = VDFA(i,j,s) + DFTAX(i,j,s) + VIFA(i,j,s) + IFTAX(i,j,s) = VDFM(i,j,s) + VIFM(i,j,s)$
- For $i \in ENDW\_COMM$ ::
  $VFA(i,j,s) = VFM(i,j,s) + ETAX(i,j,s)$

Zero profits

- for $j \in PROD$

$$VOA(j,s) = \sum_{i \in TRAD} VFA(i,j,s) + \sum_{i \in ENDW} VFA(i,j,s)$$

- for $i \in ENDW$

$$\sum_{j \in PROD} VFM(i,j,s) = VOM(i,s) - HTAX(i,s) = VOA(i,s)$$

Incomes and expenditures

- Regional expenditures

$$EXPENDITURE(r) = \sum_{i \in trad} [VPA(i,r) + VGA(i,r)] + SAVE(r) =$$

- equals regional income

$$= INCOME(r)$$

Income consists of

- factor income minus depreciation
- taxes

$$
\begin{aligned}
\text{INCOME}(r) = & \sum_{i\varepsilon ENDW} VOA(i,r) - VDEP(r) \\
& + \sum_{i\varepsilon NSAV} VOM(i,r) - VOA(i,r) \\
& + \sum_{j\varepsilon PROD} \sum_{i\varepsilon ENDW} VFA(i,j,r) - VFM(i,j,r) \\
& + \sum_{i\varepsilon TRAD} VIPA(i,r) - VIPM(i,r) \\
& + \sum_{i\varepsilon TRAD} VDPA(i,r) - VDPM(i,r) \\
& + \sum_{i\varepsilon TRAD} VIGA(i,r) - VIGM(i,r) \\
& + \sum_{i\varepsilon TRAD} VDGA(i,r) - VDGM(i,r) \\
& + \sum_{j\varepsilon PROD} \sum_{i\varepsilon TRAD} VIFA(i,j,r) - VIFM(i,j,r) \\
& + \sum_{j\varepsilon PROD} \sum_{i\varepsilon TRAD} VDFA(i,j,r) - VDFM(i,j,r) \\
& + \sum_{i\varepsilon TRAD} \sum_{s\varepsilon REG} VXWD(i,r,s) - VXMD(i,r,s)
\end{aligned}
$$

Źródło: Hertel, Tsigas (1997) Structure of GTAP

Production structure

```
   Production structure
   --------------------

                           qo(j,r)  [ao(j,r)]
                             /\
                            /  \  <----- CES
                           /    \
                          /      \
                         /        \
     [ava(j,r)]  qva(j,r)       qf(i,j,r)  [af(i,j,r)]
                   /|\                 /\
CES ----->        / | \               /  \  <------ CES
                 /  |  \             /    \
                /   |   \           /      \
               /    |    \         /        \
            Land  Labor Capital Domestic     Foreign
                qfe(i,j,r)       qfd(i,j,r)  qfm(i,j,r)
               [afe(i,j,r)]
```

Production function

- CES has this linearized form

$$q_1 = \sigma(p - p_1) + q,$$

where q_1 is the factor demand, q is output volume, p i p_1 are output and factor prices, and σ is the elasticity of substitution.

- Quite handy. Special cases:
  - Cobb-Douglas: $\sigma = 1$
  - Leontief: $\sigma = 0$
- All producer equation will have:
  - demand equation
  - cost equation (like in our models in GAMS)

Value added and intermediate use

```
EQUATION VADEMAND
# Sector demands for primary factor composite #
(all,j,PROD_COMM) (all,r,REG)
qva(j,r)
  = qo(j,r) + ESUBT(j)*[pva(j,r) - ps(j,r)];

EQUATION INTDEMAND
# Industry demands for intermediate inputs,
# including CGDS sector
(all,i,TRAD_COMM) (all,j,PROD_COMM) (all,r,REG)
qf(i,j,r)
    = qo(j,r) + ESUBT(j)*[pf(i,j,r) - ps(j,r)];
```

Factor demand

```
EQUATION ENDWDEMAND
# Demands for endowment commodities
(all,i,ENDW_COMM) (all,j,PROD_COMM) (all,r,REG)
qfe(i,j,r)
 = qva(j,r) - ESUBVA(j) [pfe(i,j,r) - pva(j,r)];

EQUATION VAPRICE
# Effective price of primary factor composite
#  in each sector/region
(all,j,PROD_COMM) (all,r,REG)
pva(j,r)
 = sum(k,ENDW_COMM, SVA(k,j,r) * pfe(k,j,r));
```

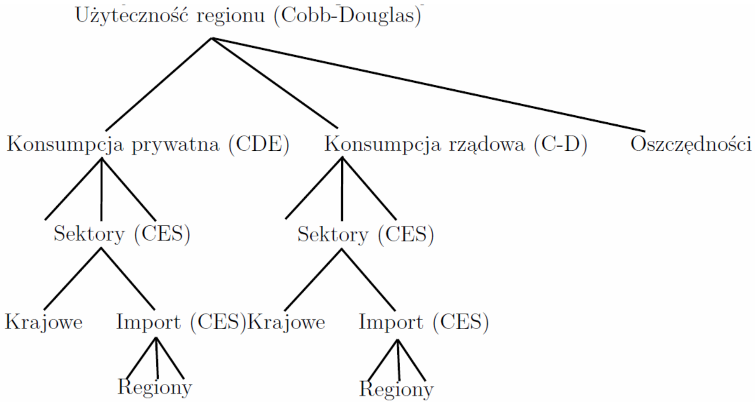
Domestic and imported intermediate goods

```
Equation INDIMP
# industry j demands for composite import i #
(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,s,REG)
    qfm(i,j,s) = qf(i,j,s)
       - ESUBD(i) * [pfm(i,j,s) - pf(i,j,s)];

Equation INDDOM
# industry j demands for domestic good i #
(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,s,REG)
    qfd(i,j,s) = qf(i,j,s)
       - ESUBD(i) * [pfd(i,j,s) - pf(i,j,s)];

Equation ICOMPRICE
# industry price for composite commodities #
(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)
    pf(i,j,r) = FMSHR(i,j,r) * pfm(i,j,r)
       + [1 - FMSHR(i,j,r)] * pfd(i,j,r);
```

Import aggregate

```
Equation IMPORTDEMAND
# regional demand for disaggregated
# imported commodities by source (HT 29)  #
(all,i,TRAD_COMM)(all,r,REG)(all,s,REG)
    qxs(i,r,s)
        = -ams(i,r,s) + qim(i,s)
        - ESUBM(i) * [pms(i,r,s)
                    - ams(i,r,s) - pim(i,s)];

Equation DPRICEIMP
# price for aggregate imports (HT 28) #
(all,i,TRAD_COMM)(all,s,REG)
    pim(i,s)
       = sum(k,REG, MSHRS(i,k,s)
                 * [pms(i,k,s) - ams(i,k,s)]);
```

Preferences



Źródło: opracowanie własne na podstawie dokumentacji modelu