



# ADAM and EMMA

A Danish Dynamic Multisectoral  
Macroeconometric Model and its  
Environmental Satellite Model

<http://www.dst.dk/adam>

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# Disposition

- Brief history
- Institutional setup.
- Builders and users, division of labour.
- Users of the model
- Use of the model
- Databank
- Equations
- Properties

# History of the ADAM model, I

- Development of a model was started in 1966 by Professor Ellen Andersen at University of Copenhagen together with various government institutions
- In 1972 the equations were solved for the first time and in 1973 there was a systematic use of it for forecasting
- In 1974 the model was named ADAM (**Annual Danish Aggregated Model**) and StatisticsDenmark took over the model
- In 1979 the model was based explicitly on input/output and in 1982 the number of sectors was extended from 6 to 18 and later to 19

## History of the ADAM model, II

- In 1979 TSP was used as the simulation program
- A dynamic version of the “Linear Expenditure System” was implemented in 1982 together with a new general consumption function with error correction
- A new simulation program for PC was introduced (PCIM)
- In 1987 the consumption function ”broke down” and private wealth was introduced in the equation (helped a lot)
- In 1995 a factor demand system was implemented

# Builders and users of the ADAM model

- Clear division between builders and users
  - The "Model Group" at Statistics Denmark build and maintain the model and supply services for the users
  - Users can subscribe to the model (8-10,000 \$ per year), subscribe to the databank only, and/or buy ad-hoc analysis and attend courses (150\$ for 2 days). Publish analysis
- The "Model Group" at Statistics Denmark
  - Staffed with 6 economists and 6 students
  - Financed through the government budget and various revenues
    - Subscriptions, ad-hoc analysis and courses
  - Board of directors decides on the annual workplan
  - Board of advisors comment on work during the year (main users)
  - Independent of interests from users of the model.

## The "Model Group"

- Maintenance of databank
- Maintenance of model (correction of errors for new version)
- New developments (for new versions)
- Documentation
- Ad-hoc help to users (hotline)
- Preparation and holding of courses for new users
- Forecasts
  - 8 years forecast based on latest forecast from the Ministry of Finance (3 times a year)
  - 75 years forecast to use as base run in analysis

# The Users

- Actual forecasting based more or less (or not at all) on the official forecast from the Model Group
- Various analysis
- Can replace parts of the model with own equations, but it requires some insight to do it
- Gives feedback to the Model Group and makes suggestions

# Division of labour, good or bad?

- Advantages
  - Democratic control. Only one well known model, well documented enhances transparency. (Users must make own assumptions public).
  - Independence of user interest. Broad focus on all aspects of the model and its properties
- Disadvantages
  - Risk of "cultural gap" between users and builders. Builders must be aware of future "hot topics". Feedback from users.
  - Risk of "lazy" forecasters. They should not just take the official forecast, but prepare their own in detail.

## Who are the users? I

- Two main users are the Ministry of Finance and the Ministry of Business and Economic Affairs
- Other Government institutions, Ministry of Taxation, Energy Agency,
- Major Banks. Makes their own forecast, important voices in the economic debate.
- Labour market institutions. Organisations of Employers and Employees
- Various research institutions
- Statistics Denmark (Externally funded projects)

## Who are the users? II

### Universities

- Problem 1: Using large scale econometric models requires continuous building and maintaining of human capital related to the model and software
- Problem 2: University people (at least in Copenhagen) are more interested in small ad-hoc models and frontline theoretical research
- Problem 3: ADAM is considered to be an old fashioned tool

# What do they use it for? I

## Economic Ministries

- The databank: Long consistent time series. THE resource for national accounts data and public finances.
- Short term forecast: Keeping track of the business cycles, and public finances and for drawing up the government budget, budget control. Many of the endogenous variables fixed by the user.
- Medium term forecasts and economic planning: Guideline for public finances. More equations run freely
- "What if" analysis
- Environmental consequences of economic policy
- Major analysis (pension problems etc.)

# What do they use it for? II

## Other users

- Databank (best collection of readily available economic statistics in Denmark)
- Short term forecasts (banks and organisations)
- "What if" analysis (banks and organisations)
- Indirekt effects of changes in taxes (Ministry of Taxation)
- Long term structural analysis, and multiplier experiments (energy agency, research institutions)

# The databank - ADAMBK

- Time series of about 3500 variables, most of them used in the model (only macrovariables, no matrices and vectors)
- Build and maintained with AREMOS software.
- Customers get it in AREMOS, PC-AXIS and Excel (previously some also got it in **pdg**-format)
- Maintained continuously. New official versions 3 times a year
- Sent to customers the same day or a few days after major news from national accounts and government finances (the advantage of being in the same house)

# Timetable for updating ADAMBK

		<b>Final years</b>	<b>Preliminary years</b>
<b>Ultimo 2001</b>		<b>1966 – 1998</b>	<b>1999 – 2000</b>
<b>March 2002</b>	<b>The first 2001 data are ready</b>	<b>1966 – 1998</b>	<b>1999 – 2001</b>
<b>July 2002</b>	<b>More 2001 data, revisions</b>	<b>1966 – 1998</b>	<b>1999 – 2001</b>
<b>December 2002</b>	<b>More 2001 data, new final year, i/o tables for 1999</b>	<b>1966 – 1999</b>	<b>2000 – 2001</b>

## The model, overview

- Keynesian tradition. Income multiplier: Demand determines production, which determines income which determines demand etc.
- In the long run; more "classical" results. Crowding out (predominantly through the foreign trade) means that fiscal policy has no effect in the long run
- Approximately 4000 variables in 2500 equations.
- "Only" 19 industries (sectors), 11 consumption goods and 4 investment types, 10 export goods and 15 import goods according to the SITC 1 level
- With regard to both volumes and prices these different groups are tied together by i/o coefficients

# Equations

- In the appendix you will find a simple system of equations representing the general features of the model. The dynamic structure of the model, the degree of disaggregation and specific features, which may be important under some circumstances, have been left out.
  - *f* in front means fixed price value
  - *yd* means disposable income
  - *uim, uib* are usercost expressions (machinery and buildings)
  - *dt<i>* are timetrends
  - The rest is pretty much selfcontained

# Consumption / saving I

On the basis of Modigliani's (1980) life cycle hypothesis we can write total consumption as

$$C^* = Y_d^{\beta_1} W_{cp}[-1]^{1-\beta_1} \quad (W_{cp} \text{ is ultimo dated, homogeneity})$$

and in logarithms

$$\log(C^*) = \beta_0 + \beta_1 \log(Y_d) + \beta_2 \log(W_{cp}[-1]) \quad (\beta_1 + \beta_2 = 1)$$

Thus in the long run consumption is determined by the level of disposable income and private wealth. Beta's are elasticities

## Consumption / saving II

In the short run consumption is determined in an error-correction model (small letters indicates logarithms, D indicates differences)

$$D(c) = \alpha_0 + \alpha_1 D(y) + \alpha_2 D(w_{t-1}) + \alpha_3 c_{t-1} + (\alpha_0 + \alpha_1 y_{t-1} + \alpha_2 w_{t-2})$$

Now  $\alpha_1$  and  $\alpha_2$  are the short run elasticities. If  $\alpha_1 < \alpha_1$  : rigidity  
 A 1% increase in Yd will increase C in the first year by only 0.5%  
 In the long run it is about 0.9%

Wealth is essential. Effects often comes from the housing market

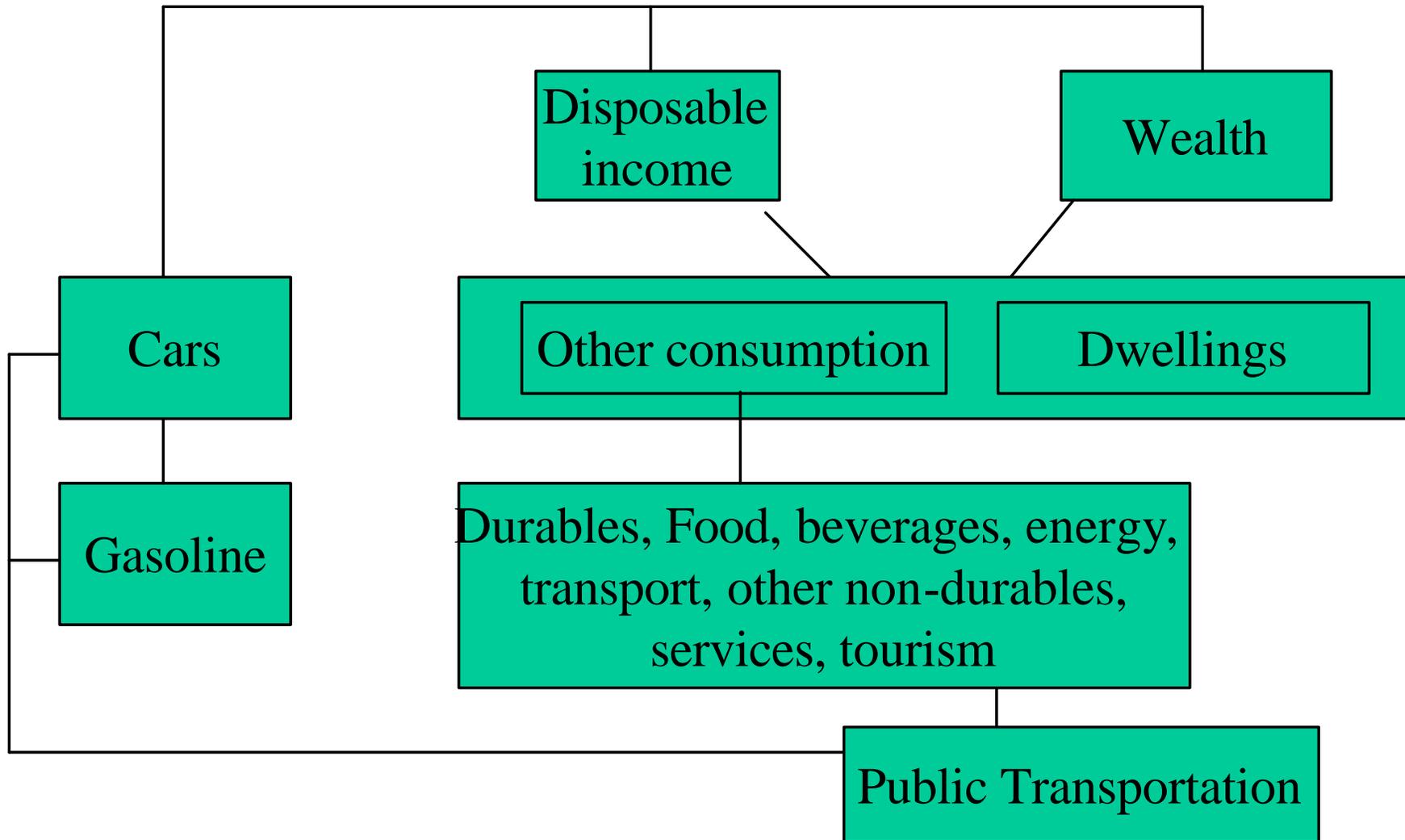
## Consumption / saving III

$C^*$  is split into what is spent on housing  $h$  and on other consumption by a CES expenditure system

$$fC_{xh}^* = \frac{C^*}{pC_{CES}} \frac{pC_{CES}}{pC_{xh}} \theta_1 ,$$

$$fC_h^* = \frac{C^*}{pC_{CES}} \frac{pC_{CES}}{pC_h} \theta_2$$

# The consumption system in ADAM



# Wages

- The wage equation is central. It determines the competitiveness and thereby foreign trade. The relation between the wage and usercost of capital determines the composition of labour and capital in production.
- Theoretical starting point in the "Right to manage" model. The wage is the result of negotiations between employers and employees' organisations. The labour organisation is supposed to be aware of the connection between increasing wages and decreasing employment.
- In the long run wages will depend on the price level, productivity, unemployment rate, degree of compensation of unemployed and indirect wage costs (employers social contributions etc.)
- In the short run also taxes have effect

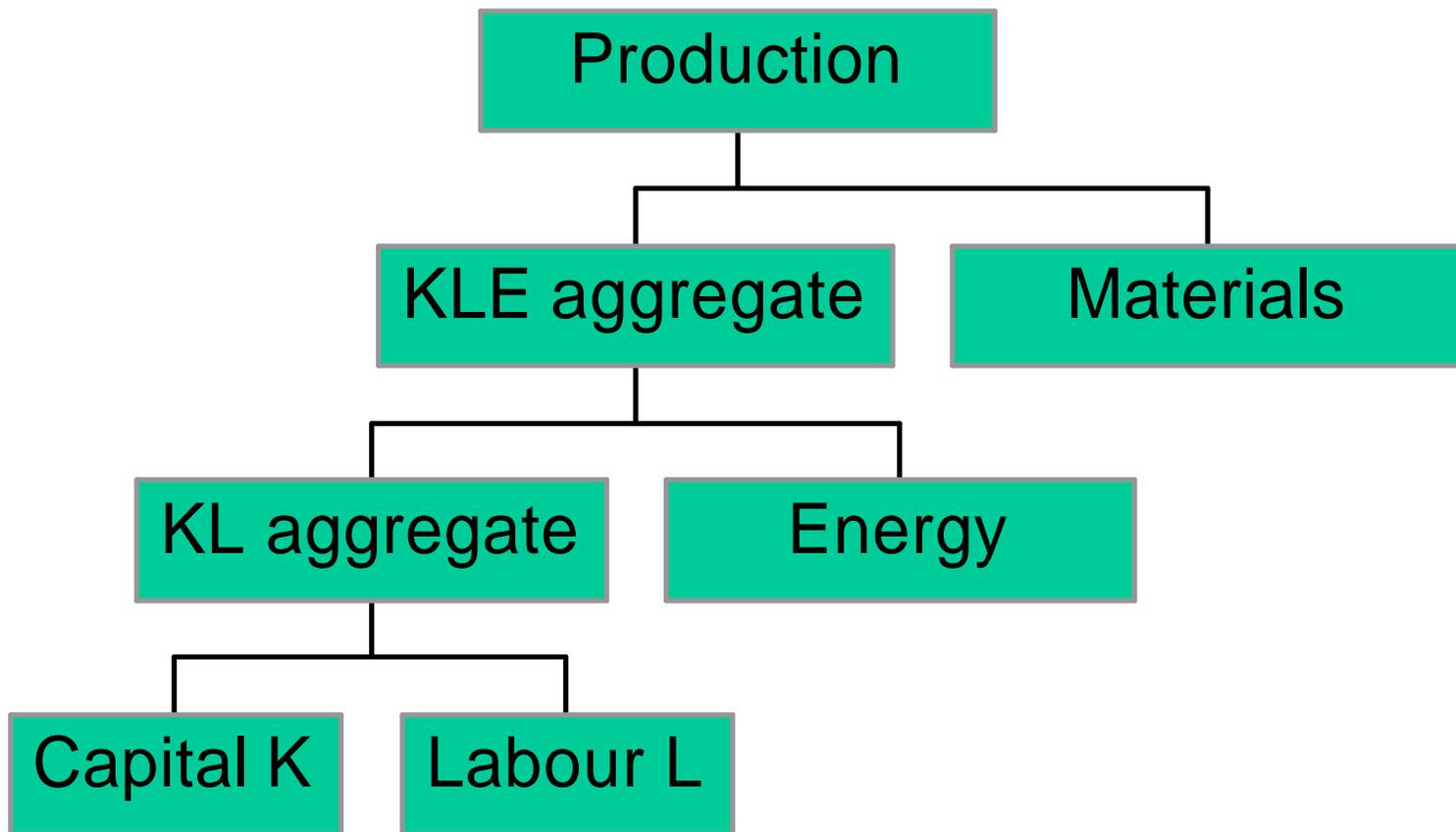
## Wages II, Elasticities

Effect on wages	1. year	2. year	long run
Output price	0.166	0.333	0
Consumer price	0.065	0.130	0
Income tax	0.065	0.130	0
Indirect wage costs	0	0	-1
Productivity	0.110	0.110	1
Unemployment rate	0	-0.831	-4.56
Degree of compensation	0	0.128	0.702
Value added price	0	0	1

# Factor demand I

- Equations for the long run demand for capital, labour, energy and materials are derived from a production-function framework ( $Y = (K, L, E, M)$ ) and cost minimisation. Each of the four factors are dependent on all four factor prices and  $Y$ .
- Factor-augmenting technical progress is build in
- $Y = F(e_K K, e_L L, e_E E, e_M M)$
- Dynamic adjustment to increases in  $Y$  by error-correction equations. Capital adjusts very slowly. After a 1% increase in  $Y$   $M$  increases by 1% at once, but  $K$  and  $E$  are slow, so  $L$  must "overreact" to make up for the missing capital
- Embedded CES equations

# Embedded system $((((KL)E)M)$



## Other "blocks" in the model

- Very elaborated on taxes, and public finance, because of wishes from the users.
- Pension "block", because it is a hot issue these years
- A monetary block that takes care of interest rates, banks etc.

# Software

- Software for running the model is called PCIM
- Commandline based
- Model is compiled in Fortran
- Only used for this model. The author is now subdirector of the Danish National Banks. Not much time, vulnerable solution. Maybe G7 Interdyme??
- However, PCIM is well established and known by all the customers, so it will not be easy to replace

# Properties of ADAM

- The properties are examined very carefully. New equations are tested in a partial model first, and if found satisfactory, the changes in the general properties of the model are examined. A seemingly "perfect" equation can be rejected after this stage.
- The properties are investigated by comparing a base-run with a new simulation with eg public expenditures raised by 1% of GDP
- In the hand-out there are 4 such experiments

# EMMA

- EMMA (Energy and eMission Models for ADAM) is a system of satellite models, which is linkable with ADAM making it possible to do detailed calculations on energy consumption and emissions.
- The purpose of developing environmentally related models for ADAM is to have the ability to evaluate the environmental development in line with and consistent with the economic development.
- In order to make ADAM applicable for analysis of environmental issues it is necessary to complement ADAM with an environmentally relevant disaggregation of central economic variables, together with models describing the relations and the environmental issues in question.

## EMMA II

- In the next page, ADAM and EMMA relationships are displayed:
  - Household consumption of energy, in the subgroups ‘transport energy’ and ‘other energy’
  - Industry consumption of energy by 19 industry groups
  - A number of macroeconomic variables relevant for energy consumption ( such as stocks of cars and houses, income, prices etc.)
- Now Emma determines household and industry energy consumption in more detail, namely the 6 energy types ‘electricity’, ‘district heating’, ‘natural gas’, ‘liquid fuels’, ‘solid fuels’ and ‘transport fuels’. Emissions of CO<sub>2</sub>, SO<sub>2</sub> and NO<sub>x</sub> are linked to each. (Today soon 8 types)

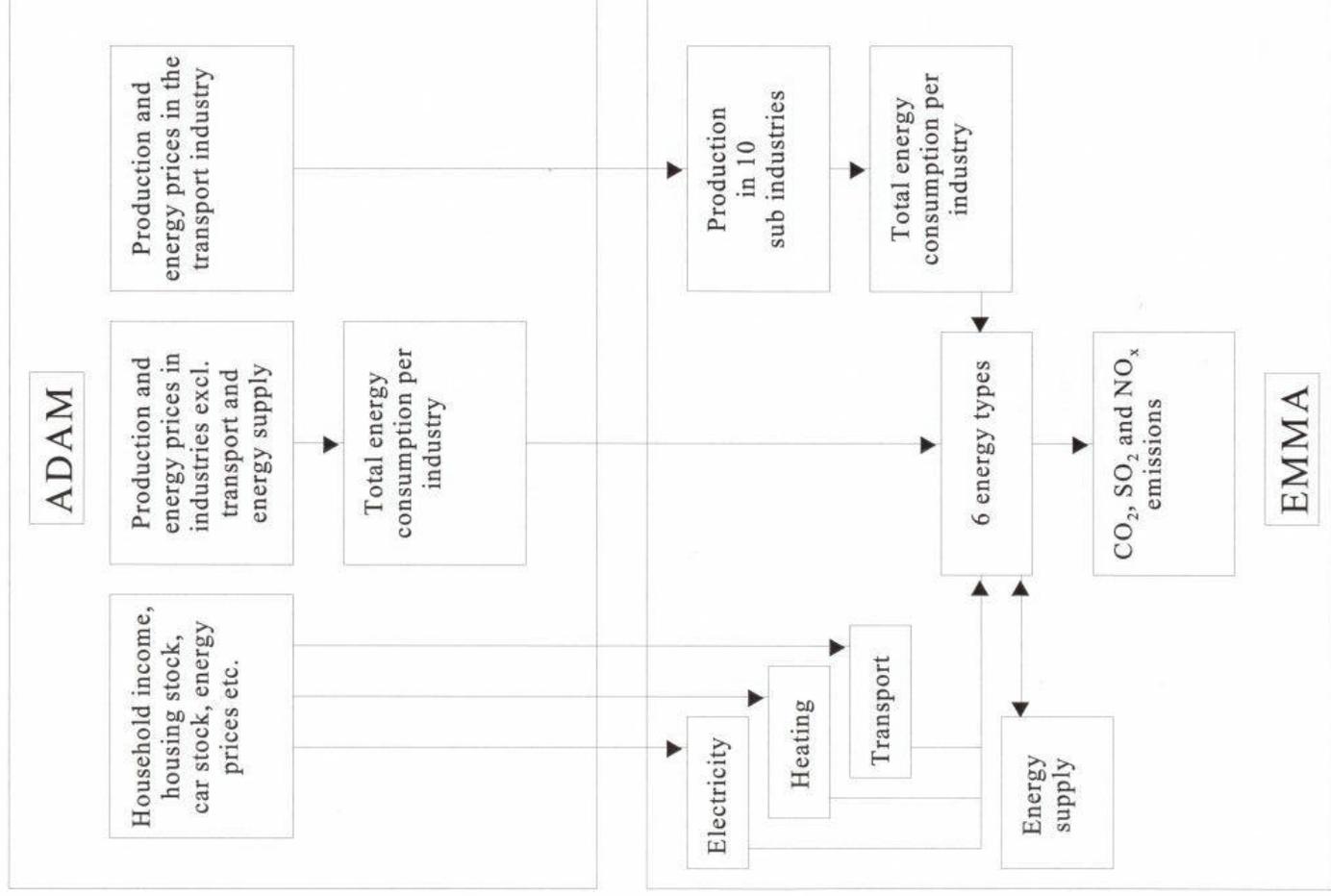


Figure 2.1. Structure in EMMA and connection with ADAM

**Demand for goods and services and demand for production factors**

Private consumption	$fCp = F\left(\frac{Yd}{pcp}, \frac{Wcp}{pcp}\right)$	1
Optimal capital stock, buildings	$fKb^w = F\left(fY, \frac{uib/\overline{dikb}}{py}\right)$	2
Optimal capital stock, machinery	$fKm^w = F\left(fY, \frac{lna/\overline{dtq}}{uim/\overline{dtk}}\right)$	3
Private investments, d = b, m	$fIp<d> = F(fK<d>^w, fK<d>)$	4
Capital stock, d = b,m	$fK<d> = fK<d>_{-1} + fIp<d>$	5
Employment	$Q = F(fY, fKm) + \overline{Qo}$	6
Demand for dwellings	$fKbh^w = F\left(\overline{U}, \frac{Yd}{\overline{U} \cdot pcg}, \frac{uibh}{pcg}\right)$	7
House prices	$phk = F\left(\frac{fKbh^w}{fkbh}\right)$	8
Capital stock, dwellings	$fKbh = F\left(\frac{phk}{pibh}, \frac{fKbh^w}{fkbh}\right)$	9
Private investments, dwellings	$fIbh = Diff(fKbh)$	10
Exports	$fE = F\left(\overline{fEe}, \frac{pe}{pee}\right)$	11
Final demand	$fD = fCp + \overline{fCo} + fIp + fIbh + fE$	12

### Supply of goods and services

Imports  $fM = F(fD, \frac{\overline{pm}}{py})$  13

Gross domestic product  $fY = fD - fM$  14

### Labour market

Labour supply  $Ua = F(Q, \bar{U})$  15

Unemployment  $Ul = Ua - Q$  16

### Prices

Domestic prices  $p<d> = F(\frac{lna}{dtq}, \frac{uim}{dtk}, uib, \overline{pm}, \overline{tsi})$  17  
d = y, cp, co, im, ib, ibh, e

Wage  $lna = F(pcp, \frac{fY}{Q \cdot Hgn}, Ul)$  18

Usercosts  $ui<d> = pip<d> \cdot (iwbz - R(pip<d>), \overline{tsd})$  19  
d = b, m

### Incomes and taxes

Indirect taxes  $Si = (fY \cdot py) \cdot \overline{tsi}$  20

Factor income  $Yf = fY \cdot py - Si$  21

Direct taxes  $Sd = (Yf + Ty + Tipn) \cdot \overline{tsd}$  22

Transfers  $Ty = F(Ul, lna)$  23

Disposable income  $Yd = Yf + Tv + Tipn - Sd$  24

### Sector balances

$$\text{Net flow of interest, private sector} \quad T_{ipn} = F(iw_{bz}, \overline{iw_{bu}}) \cdot W_{pqp} \quad 25$$

$$\text{Net flow of interest, public sector} \quad T_{ion} = -iw_{bz} \cdot W_{zbg} \quad 26$$

$$\text{Net flow of interest abroad} \quad T_{ien} = F(iw_{bz}, \overline{iw_{bu}}) \cdot K_{en} \quad 27$$

$$\text{Private sector net lending} \quad T_{ipn} = Y_d - fC_p \cdot pcp - fIp \cdot pip - fIbh \cdot pibh \quad 28$$

$$\text{Private sector net lending} \quad T_{fon} = T_{ion} + S_d + S_i - \overline{fCo} \cdot pco - T_y \quad 29$$

$$\text{Balance of payments} \quad T_{fen} = T_{ien} + fE \cdot pe - fM \cdot pm \quad 30$$

$$\text{Private financial wealth} \quad W_{pqp} = W_{pqp_{-1}} + T_{ipn} \quad 31$$

$$\text{Public sector debt} \quad W_{zbg} = W_{zbg_{-1}} - T_{fon} \quad 32$$

$$\text{Foreign debt} \quad K_{en} = K_{en_{-1}} + T_{fen} \quad 33$$

$$\text{Private wealth} \quad W_{cp} = W_{pqp} + fK_{bh} \cdot phk + fK \cdot pip \quad 34$$

### Interest rate

$$\text{Domestic demand for bonds} \quad W_{pbz} = F(iw_{bz} - \overline{iw_{mm}}, W_{pqp}) \quad 35$$

$$\text{Foreign demand for bonds} \quad W_{fbz} = F(iw_{bz} - \overline{iw_{bu}}, R(\frac{I_{na}}{I_{nat}}, \frac{T_{fen}}{fY \cdot py})) \quad 36$$

$$\text{Rate of interest} \quad iw_{bz} = F(W_{zbg}, W_{pbz} + W_{fbz} + \overline{W_{nbz}}) \quad 37$$