Forest sector modeling - Finland

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Some history for Finland (in rough)

- Relatively long tradition of forest sector modelling and also use of models to support national policies:
  - Finnish scientists, Risto Seppälä & Markku Kallio were leading the development of the global forest sector model GTM at IIASA (1980-1985)
  - Before and parallel to GTM, already modelling activities on the Finnish forest sector. The logic of MESSU-model by Kuuluvainen, Seppälä & Seppälä was based on system dynamics rather than economic theory. Used for policy planning.

- M. Kallio developed a code for adapting the IIASA model for national applications:
  - in Finland, so called Mini-GTM was born soon after IIASA's GTM (policy support + applications in several masters' theses)

Some history for Finland (in rough)

- The SF-GTM was first used in Ronnila (1991). Extension of the Mini-GTM to 18 Finnish regions and RoW with the Fortran code by M. Kallio & the mill-level data by Ronnila. (Similarities to GTM, but not identical)

- Note that, tools like GAMS with integrated solvers were not available/widely used in 1980s – early 1990s. The SF-GTM solved the NLP –problem by using the method developed by Kallio and Salo (tatonnement).

- SF-GTM extended to include the forest industries in Europe at more detailed level (production capacities of paper products at company level) → addressing the impact of *imperfect competition* and *company mergers* in the paper markets (Ronnila 1995, IIASA Wp)

Some history for Finland (in rough)

- MELA forestry model simulating and optimizing the Finnish forests at stand level, first introduced in 19xx, was more and more actively used for tailored analyses since 1996.

- SF-GTM was shifted to GAMS by Ronnila. The GAMS code was further adapted to two global forest sector models
  - a global forest sector model for a Finnish forest company interested in particular of the impact of mergers (1996);
  - EFI-GTM, without the company level component and imperfect competition (1996-97).

Some history for Finland (in rough)

- SF-GTM was taken from “naftaline” and updated at Metla in 2005 and used in policy support e.g., to
  - address the impacts of forest conservation policies (METSO)
  - support the formation of national forest programme 2015.
  - make a baseline for the Finnish use of forest (Kyoto reference)
  - consider impacts of Russian wood export tax

- Development of FinFEP model by Uusivuori et al. started in 2007 at Metla. The dynamic regionalised model for wood-using sectors is now also is use.

Some history for Finland (in rough)

- For-Ener, the partial equilibrium model with supply and demand (heat and power plants, biorefineries) for forest chips at municipal level was developed in 2008 (Kallio)

- For-Ener merged to SF-GTM to allow the complete scrutiny of wood supply and demand for energy

- SF-GTM disaggregated from forest center level to municipal level in all aspects (2016).

Models on forest sector in active use

Forestry models (at Luke)

- (Motti - stand simulator)
- Mela

Partial equilibrium models for the forest sector (at Luke)

- SF-GTM
- FinFEP
- (EFI-GTM, global with Finland as a region)

General equilibrium models also exist with some forest sector details (outside Luke):

- Perhaps the most used for policy-support is **Finage** (former Vattage by J. Honkatukia).

MELA – a forest planning tool of Luke

Courtesy: Olli Salminen

MELA – a forest planning tool of Luke

- is a decision support system generated for Finnish conditions for solving such problems as:
  - what are the production potentials of forests and
  - how to manage forests to meet the overall goals of the society/forest owner now and in the future
- applied (since 1996) also in ‘practical’ forest planning, e.g. in the Forest Service, in forest companies and in the organizations of the non-industrial private forest owners

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Main features

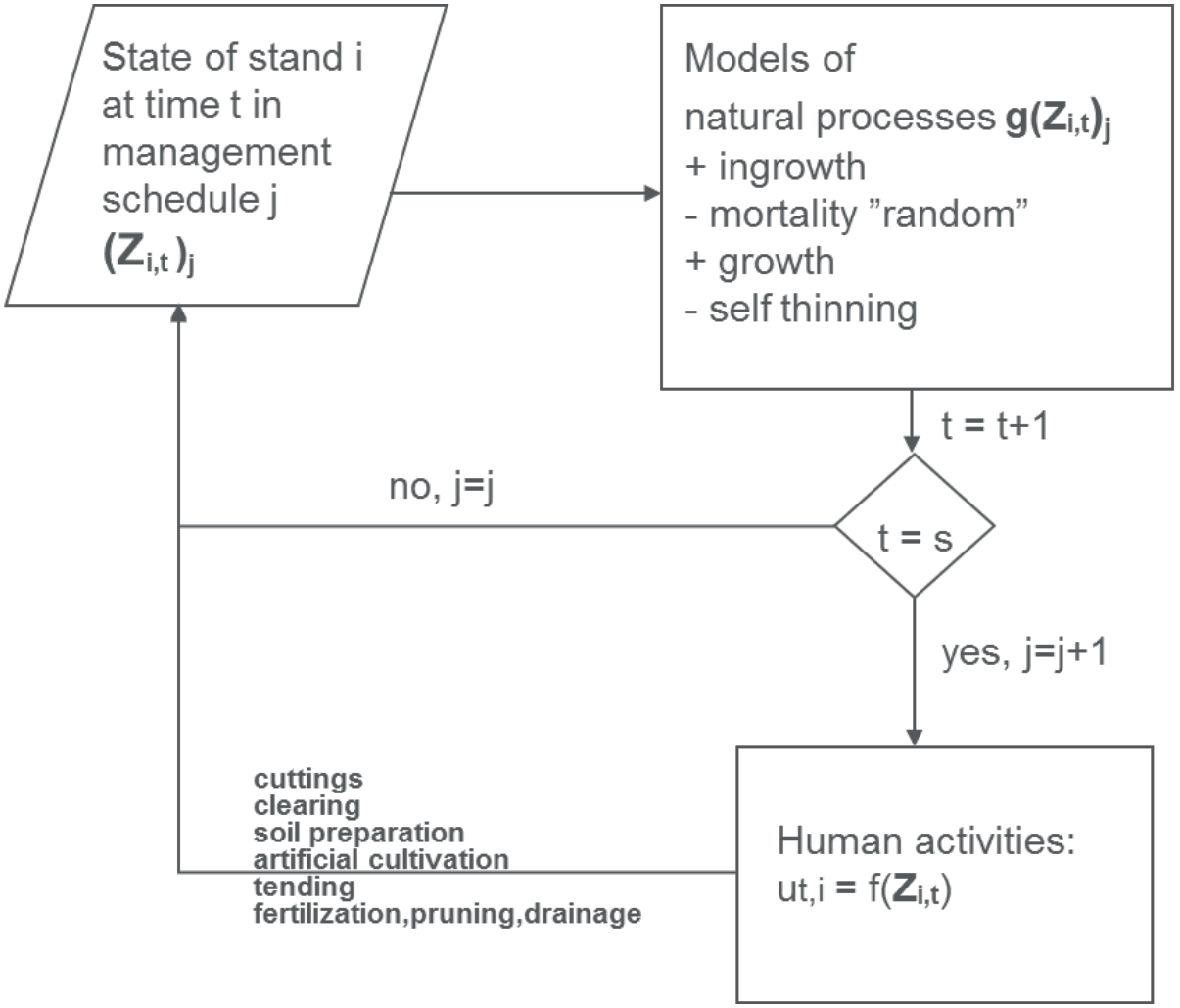
1) Simulation
   - (automated stand) simulator basing on individual tree models for producing alternative development and treatment options for stands

2) Comparison of management alternatives
   - in MELA is applied linear programming (JLP, Lappi 1992)

3) Report generator

Courtesy: Olli Salminen

Simulation of management schedules



MELA INITIAL DATA "$Z_{t=0}$"

Management unit/Sample plot data (1-32):

Inventory year
Area
X, Y coordinates
Height above sea level
Temperature sum
Owner category
Land-use category
Soil and peatland category
Site type category
Drainage category
Year from last treatment (by treatments)
Forestry board district
Forest management category

Sample tree data (1-20):

Number of stems/ha
Tree species
d1.3
Height
Age (both d1.3 and biological)
Reduction to model-based saw log volume
Origin
Height of the lowest living branch, m
Management category of the tree

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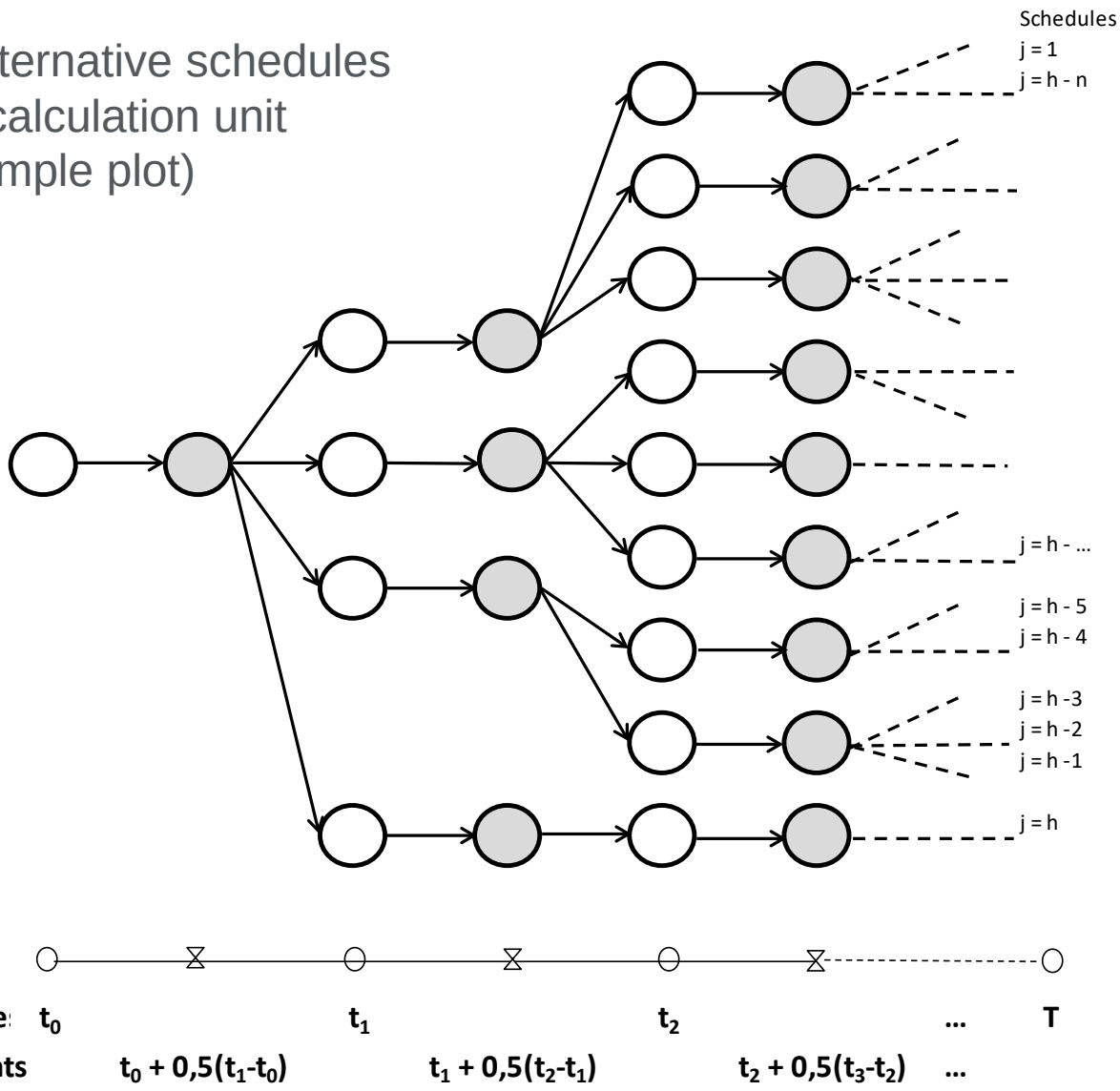
Simulation tree of alternative management schedules

1-9999 alternative schedules for each calculation unit (stand/sample plot)



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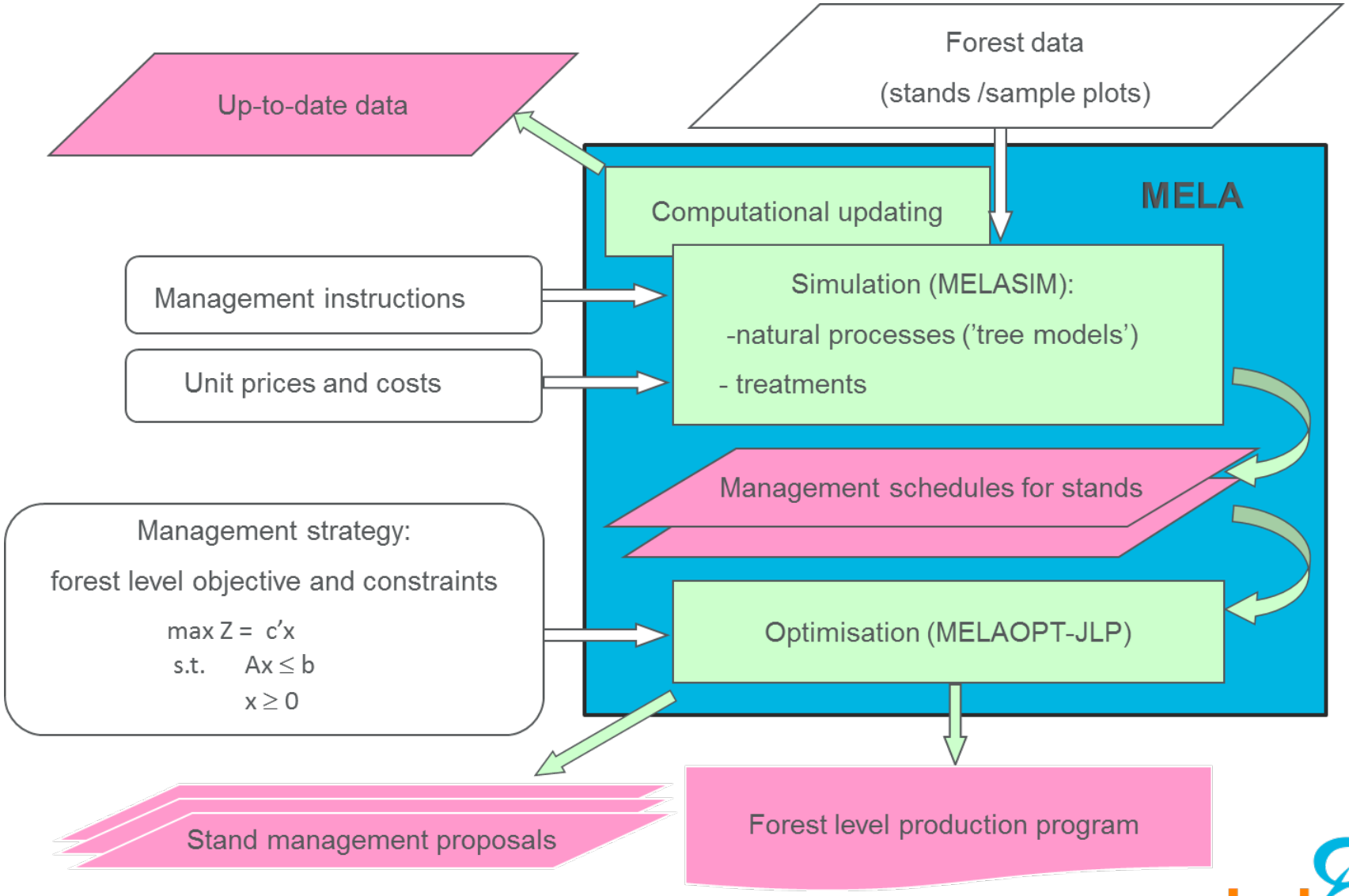
General structure of MELA analyses



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SF-GTM –model

A regionalised economic model for the Finnish wood using sectors

- Forest industries (production line level)
- Producers of heat, power and biofuels (plant level)
- Supply of domestic and imported wood fibre (supply functions)
- Transports and trade of commodities in these sectors
- Demand for the products in the exogenous sectors/consumers

- Data now defined by *municipalities* ->model can address the demand and supply of forest based commodities at a rather local level

- Also, transport flows can be considered (roads ok; rail network is yet to be added).

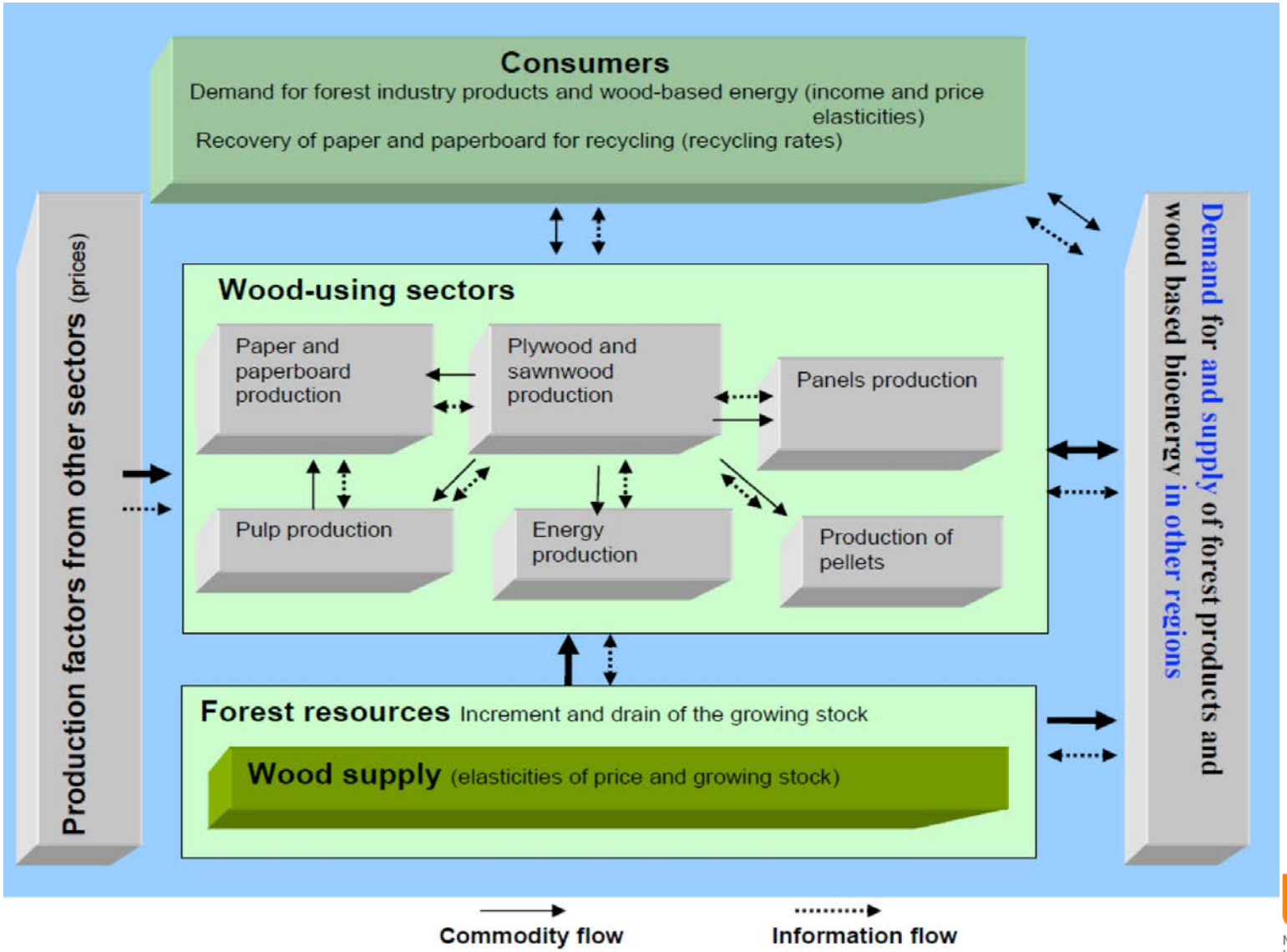
- Modelled in GAMS and very flexible to modify

SF-GTM –model is a partial equilibrium model

Like most partial equilibrium models of the kind, the model is founded on the following basic assumptions

- Market agents (consumers, producers, traders) maximize their own best whether it's welfare or profit
- ”The invisible hand” of the economy takes care that all possibilities for making an extra buck or welfare improvement are exhausted
- Markets thus find an (Nash) equilibrium where
  - No agent can do any better
  - Equilibrium prices clear the market physically: demand equals supply

Simplified model structure of SF-GTM in one region: there are 15 forest centers and about 400 municipalities as regions



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SF-GTM –model: individual players summed to one model

- Producers maximize profit $Max_{z^i} \quad \pi^i z^i - \sum_k \int_0^{z_k^i} C_k^i(z_k)\mathrm{d}z_k$

- Consumers maximize their welfare $Max_{q^i} \quad \sum_k \int_0^{q_{ik}^i} P_k^i(q_k)\,\mathrm{d}q_k - \pi^i q^i$

- Maximizing the profits from trading removes the arbitrage possibilities

$$Max_{e_k^{ij}, e_k^{ji}} \quad \sum_{jk} \left[\left(\pi_k^j - \pi_k^i - D_k^{ij} \right) e_k^{ij} + \left(\pi_k^i - \pi_k^j - D_k^{ji} \right) e_k^{ji} \right]$$

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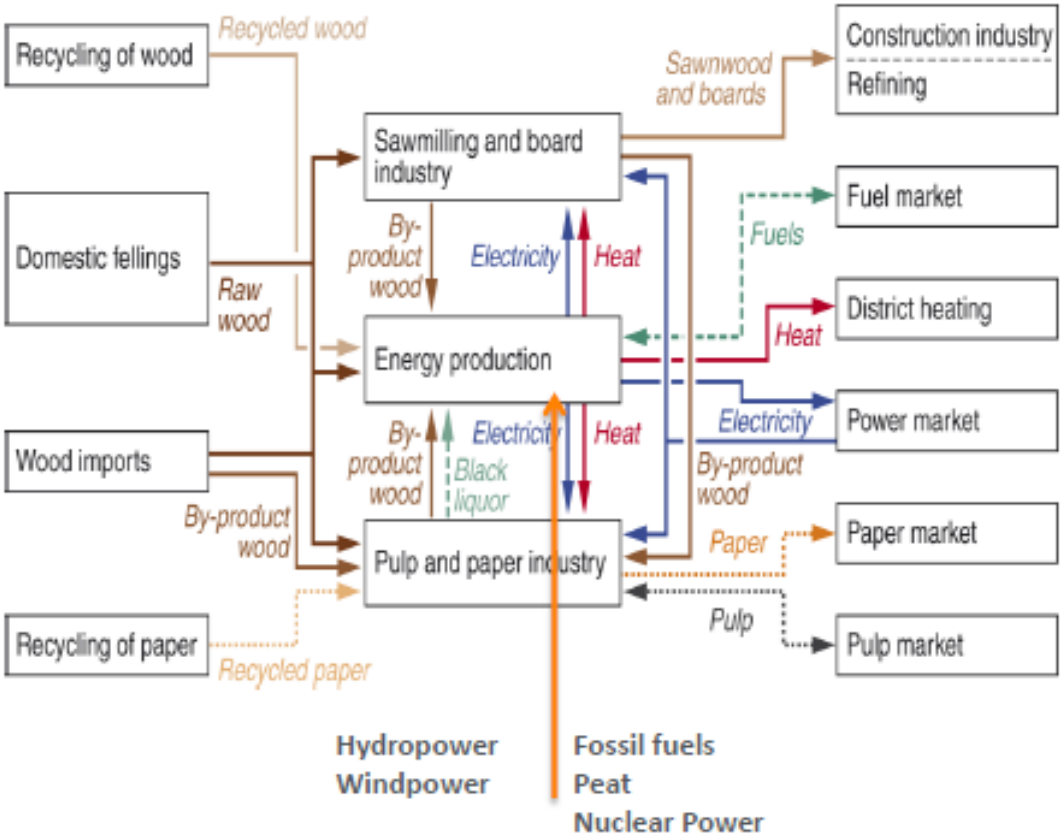
These separable problems are summed to one problem and solved with the condition that market clear and other constraints of the individual agents (Samuelson's tactic)

FinFEP -model

FinFEP-Finnish Forest and Energy Policy Model

http://urn.fi/URN:ISBN:978-952-326-119-8



The model is used in Policy Support:

- EU Climate and Energy Scheme: How to integrate the LULUCF sector (http://vnk.fi/documents/10616/1094245/VNK-EU2030+raportti+-+final.pdf/33813d7b-8907-468a-9aa4-362450b66f69)
- New Policy Designs for Natural Resource Sectors (http://urn.fi/URN:ISBN:978-952-326-020-7).

Courtesy of Jussi Uusivuori, Luke

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FinFEP (Finnish Forest and Energy Policy Model): Basic structure

Four different sectors included: energy production, the pulp- and paper industry, the sawmilling and board industries and forest-owner behavior

- Several agents (mainly a plant level approach)
- Multiple markets:
  - Endogeneity of wood markets
  - Endogenous demand for intermediate goods
  - Exogenous demand of final goods
- Partial equilibria derived for relevant markets
- Model formulated as a mixed complementarity problem (MCP) using PATH solver in GAMS modeling system. MatLab is also used.

Courtesy of Jussi Uusivuori, Luke

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