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EduMod:
Simulation and Prognostic Structural Model of the Polish Economy Including Human Capital Formation

Structure and Specification of the Model

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NARODOWA STRATEGIA SPÓJNOŚCI

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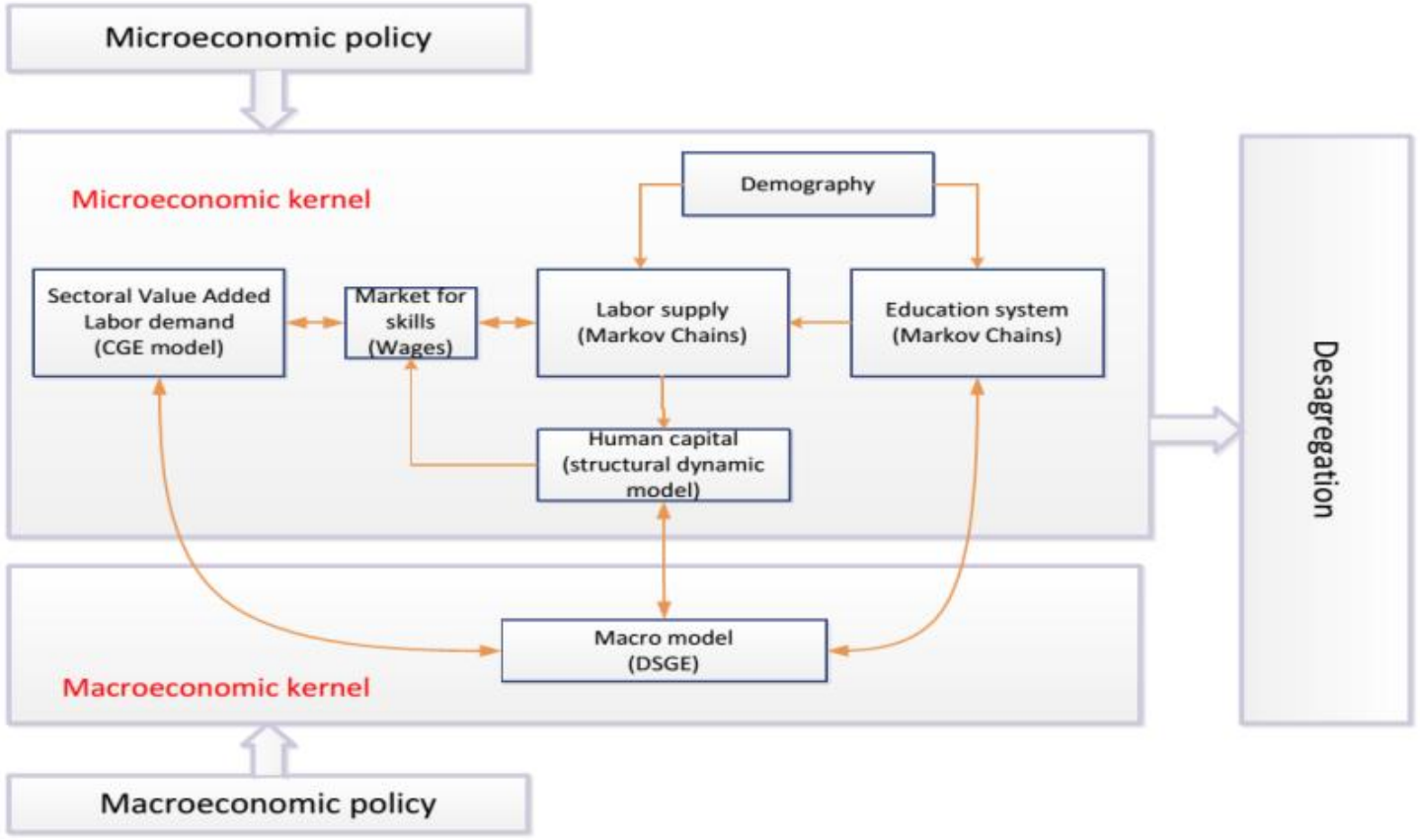
Agenda

- Overall concept of the application
- The baseline scenario
- The DSGE module
- External modules
- Design of generic module
  - Demographic module
  - Educational module
  - Higher education module
  - Labor supply module
  - Human capital module
  - Wage module

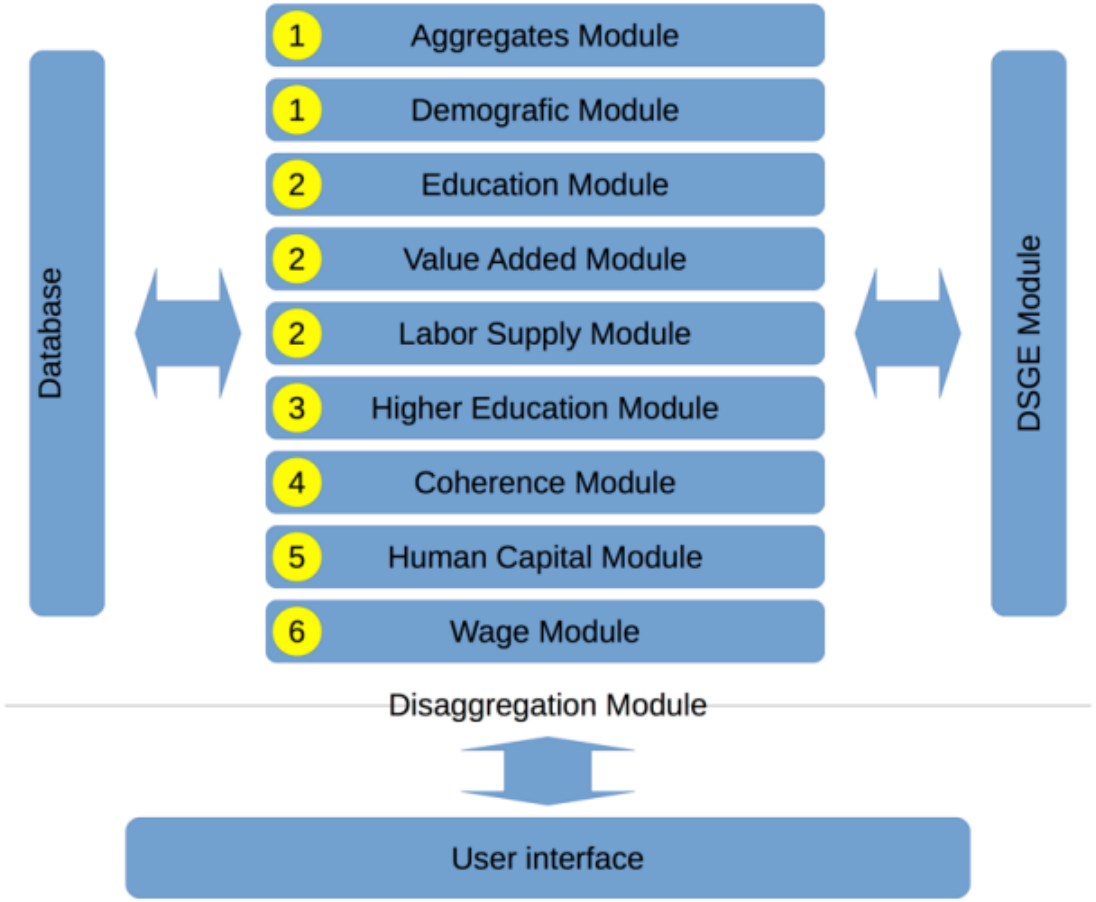
Stages of the project

- **Stage I – The basic version of the kernel of the model**
- **Stage II – Extended version of the kernel of the model**
- **Stage III – Model with full sectorial modules in the national version**
- **Stage IV – Full regional models**

Concept of the application (methodology)



Concept of the application (design of the application)



Baseline scenario (1)

- The baseline scenario is the result of processing the initial conditions (complied with the stationary point of the DSGE module) through external modules.

- Assumed initial conditions are either historical data or are imputations based on historical data.

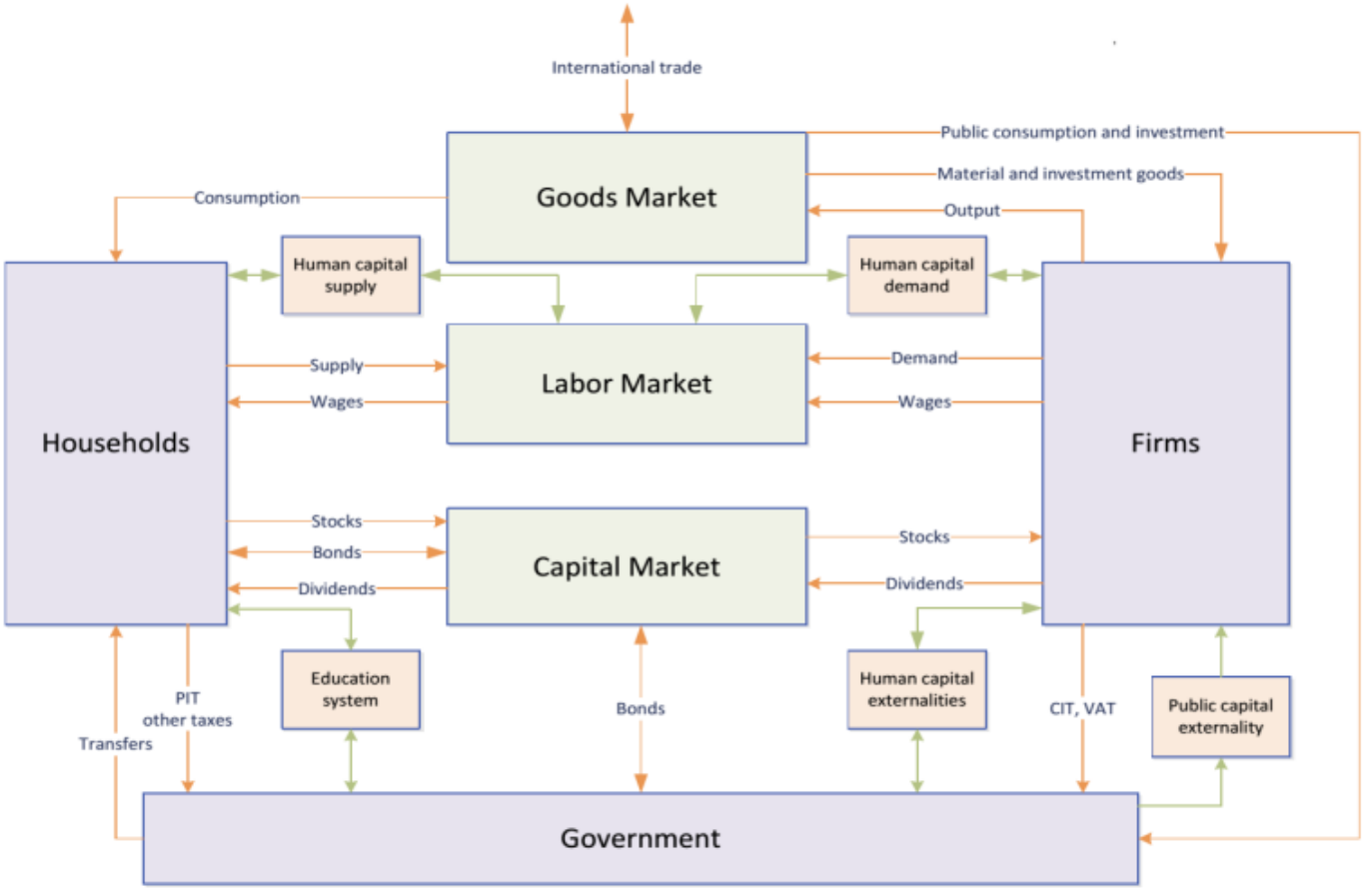
- Calibration of the modules has been carried out based on historical data.

Baseline scenario (2)

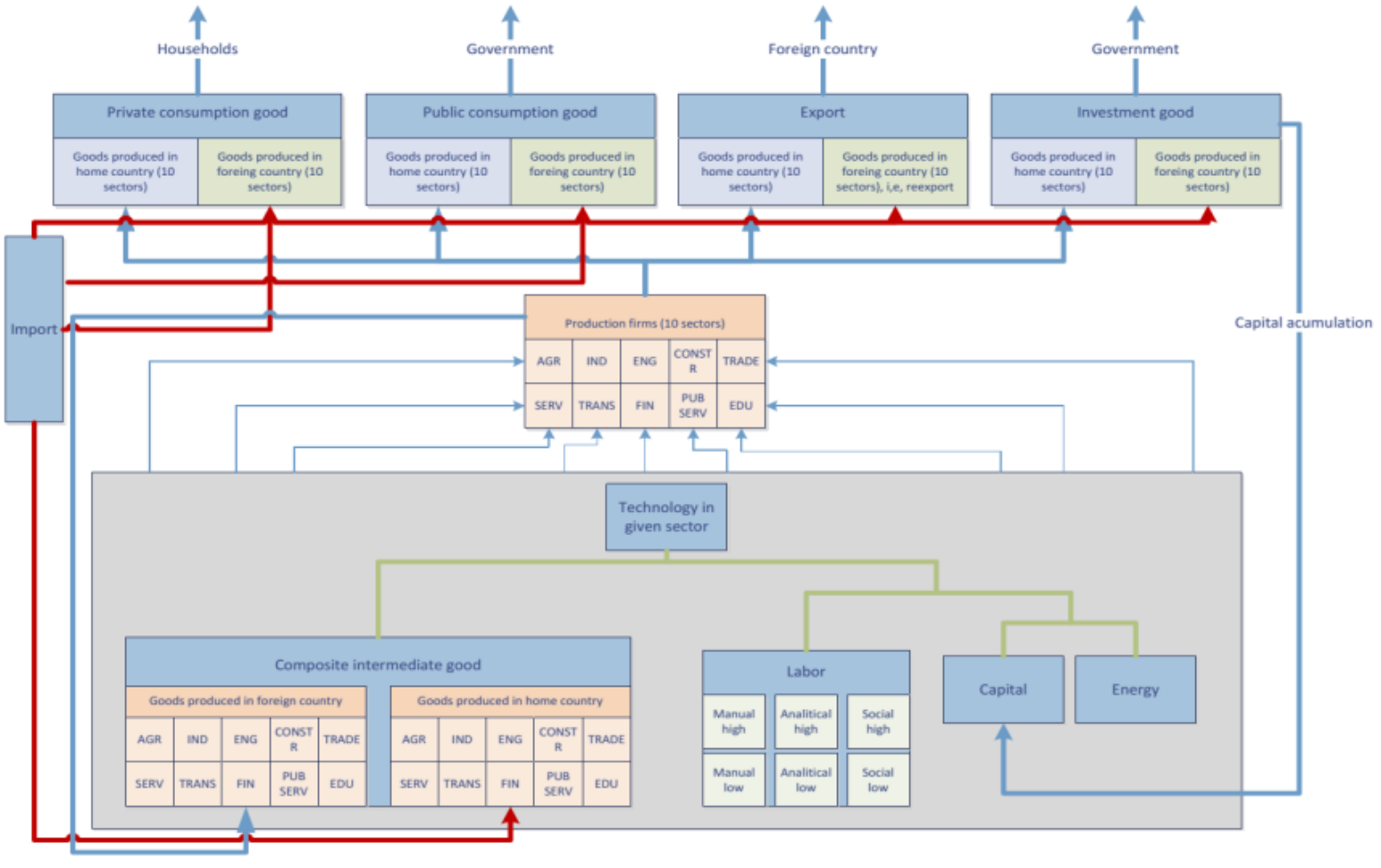
- The dynamics of main macroeconomic variables result from the convergence to the economies of most developed countries.

- Other variables depend on the one hand on the demographics and on the other on the assumed convergence to external benchmark. Structures are generally fixed within this framework and values are the result of the products.

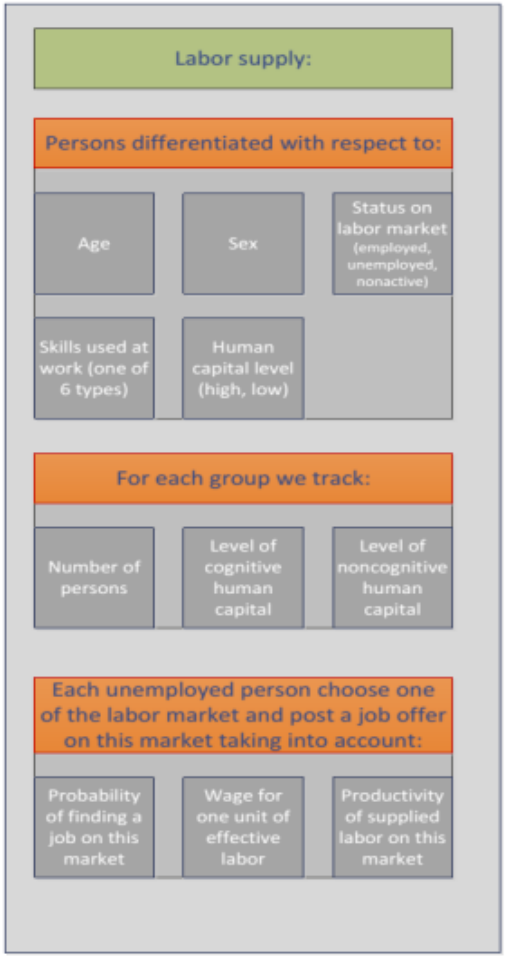
The DSGE module (1)

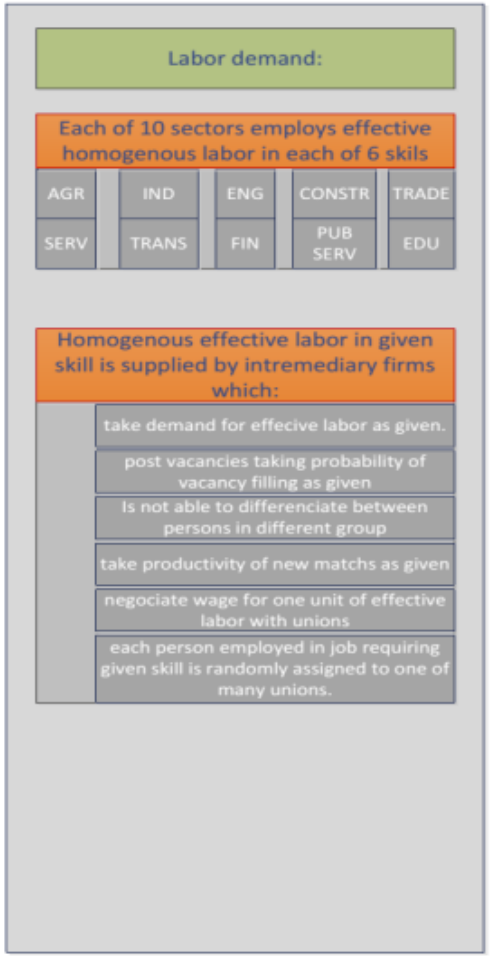


The DSGE module (2)



The DSGE module (3)





HUMAN CAPITAL
NATIONAL COHESION STRATEGY

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Design of the generic module (1)

- Each external module is implemented as a class with the conventional methods.

- All external modules are implemented in the R language (http://www.r-project.org)

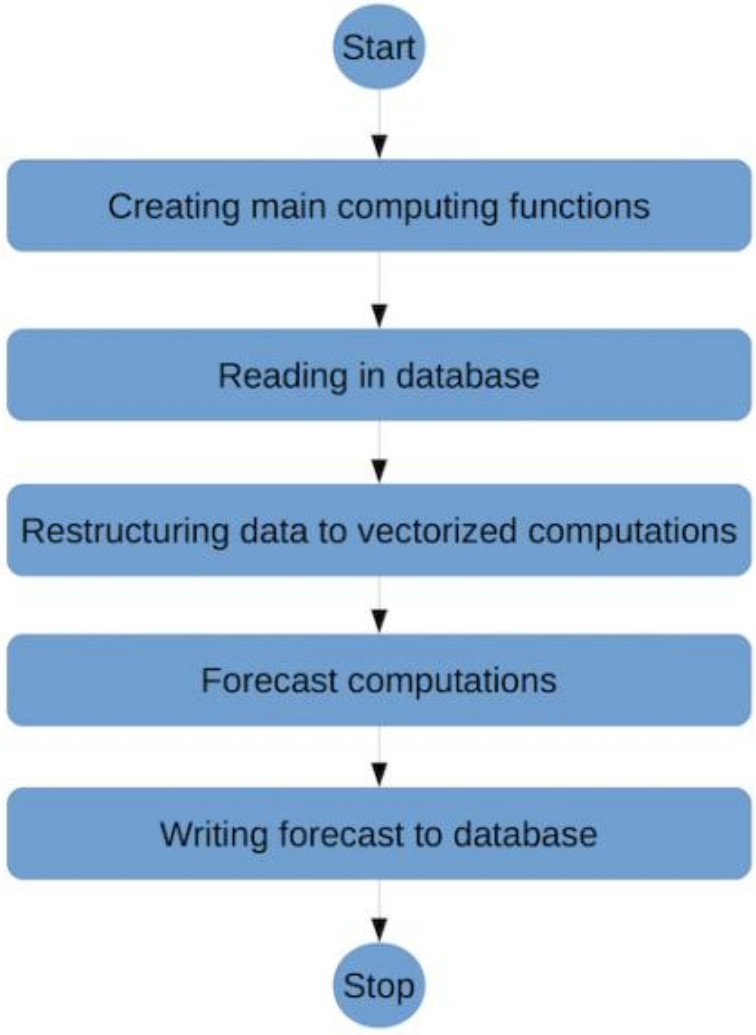
Design of the generic module (2)

- A typical sequence of calculations at the class level
  - `MODULE_customInitialize` (constructor)
  - `MODULE_setHistoryIntervalsForVarialbeIN_researcherPart` (definition of the input variables)
  - `MODULE_setFutureIntervalsForVarialbeOUT_researcherPart` (definition of the output variables)
  - `MODULE_doModuleCalculate` (calculating)
  - `MODULE_customDestructor` (destructor)

Demographic module (idea)

- A typical cohort model
- It allows to simulate the number of people by age and sex
- The model takes into account the one-year age group

Demographic module (implementation)



Demographic module (the mathematical model)

- The basic dynamics of the model is based on a recursive equation of the form

$$x_{t+1}^{s,a+1} = (1 - \rho_t^{s,a}) x_t^{s,a} + \text{migracje},$$

Demographic module (mathematical model)

- Births are modeled endogenously according to the equation:

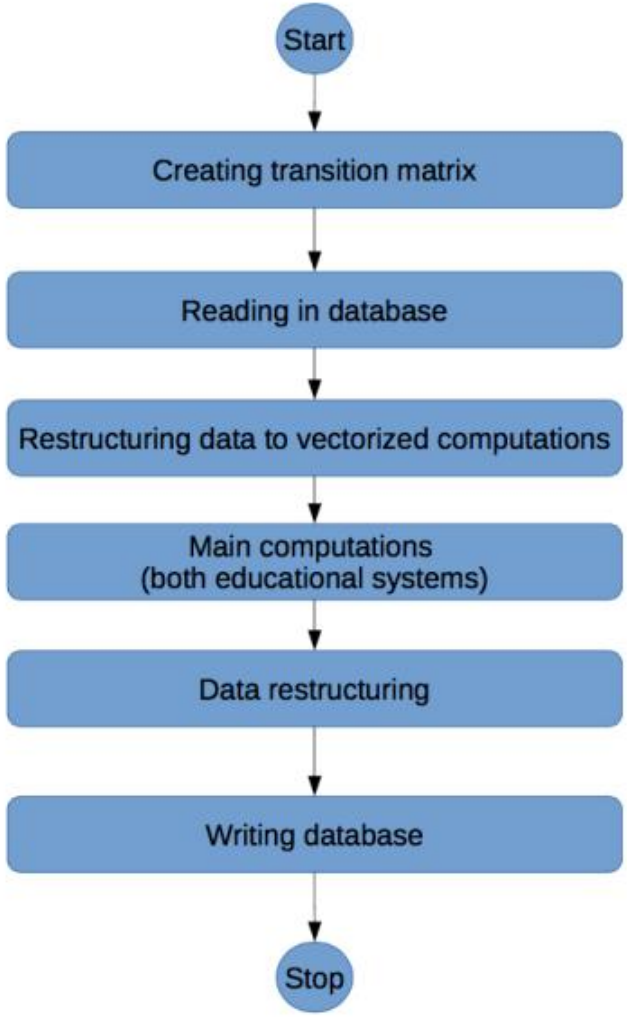
$$x_{t+1}^{s,0} = \alpha_t^s \sum_{a=15}^{49} x_t^{f,a} \beta_t^a,$$

where $\beta_t a$ is a fertility rate, whereas $\alpha_t s$ is percentage of infants of sex s

Educational module (idea)

- Educational module ranges from kindergarten to high school education and includes technical and basic vocational schools.
- The module calculates the number of children by the type of school, localisation, field, age and sex.
- The module calculates the number of graduates by age, sex and field.
- Additionally, the module calculates the number of teachers by the type of school.

Educational module (the implementation)



Educational module (the mathematical model)

- The model implemented in the educational module is based on a simple recursive equation:

$$s_{t+1} = P_1 s_t + N_1(Aw_t - Bs_t) + N_2 d_t ,$$

where s_t stands for the number of children with adequate status at time t, w_t determines the number of graduates, P_1 is transition matrix, N_1 i N_2 are the matrices of the recruitment to successive levels of study, A and B are matrices which ensure correct counting of children.

Educational module (the mathematical model)

- Recursive rule that describes the behavior of the status of graduates is of the form:

$$w_{t+1} = P_2 w_t + R s_{t+1},$$

Where matrix P_2 is transition matrix and R is the matrix of graduation, which describes graduating from the levels of study.

- Number of teachers is determined by L_t and is established in accordance with the equation

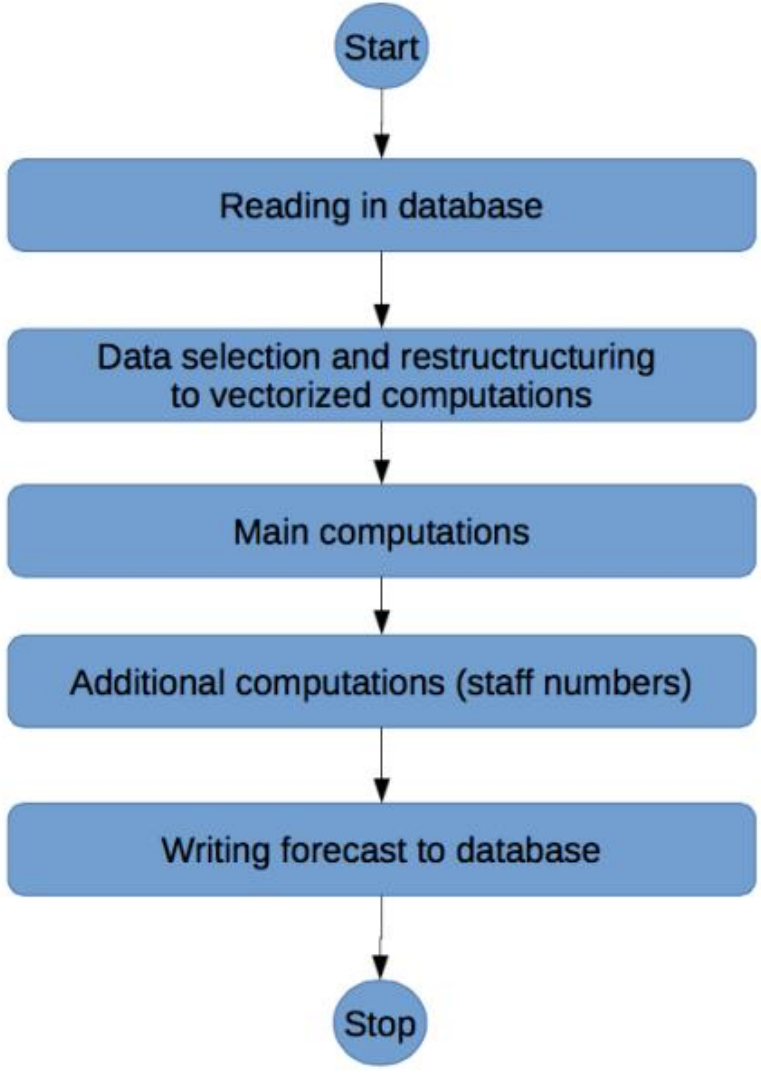
$$L_t = D s_t ,$$

where D is a matrix based on ISSR coefficients.

Higher education module (idea)

- The higher education module calculates the number of students by fields of study, mode of study, type of financing, duration, level of study, age and gender.
- Educational processes of adults after their start of professional activity are also modeled in the module.
- The module calculates the number of new graduates by age, gender and field of study.
- The module calculates the number of teachers and people working in other positions.

Higher education module (implementation)



Higher education module (mathematical model)

- The basic dynamics of the model is based on a recursive equation of the form

$$s_{t+1} = Ps_t + N(Ad_t - Bs_t),$$

where s_t is the number of students with respective status, P is the transition matrix, N is the matrix of recruitment and the matrices A and B provide the correctness of calculations.

- The number of teaching staff is calculated in the same manner as in the case of the educational module.

Higher education module (mathematical model)

- The number of people working in other public positions is calculated according to the equation

$$y_{t+1}^{P} = \alpha_0 y_t^{P} + \alpha_1 s_t^{P,S} + \alpha_2 s_t^{P,NS} + c,$$

and people working in private academies according to the equation

$$y_{t+1}^{NP} = \beta_1 s_t^{NP,S} + \beta_2 s_t^{NP,NS},$$

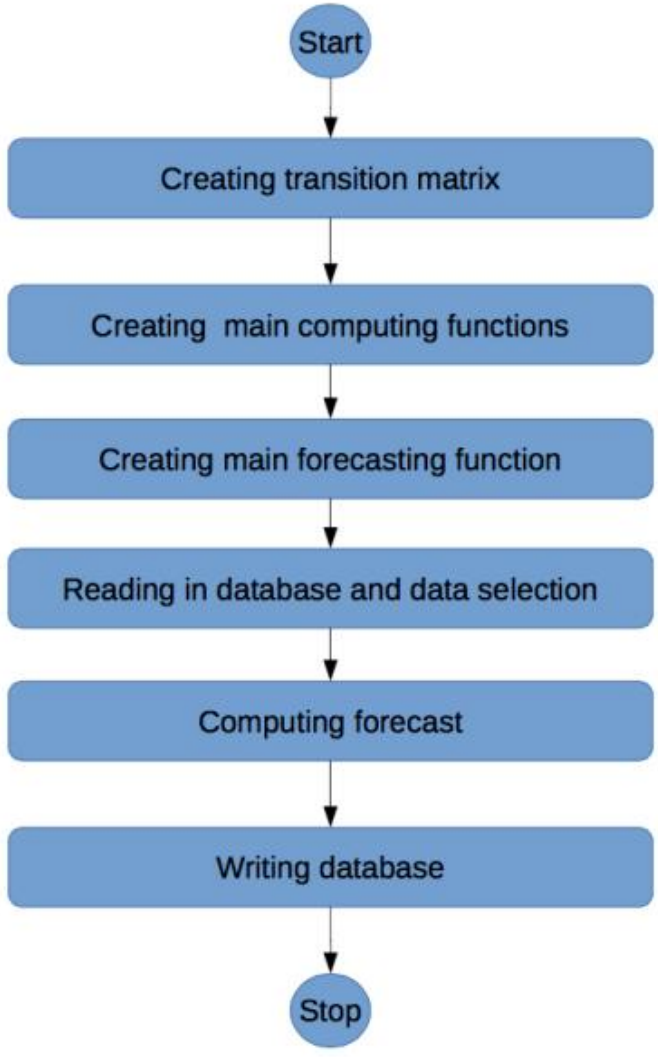
where P /NP indicates public/private, S/NS indicates full-time/part-time and y is number of workers.

Labor supply module (idea)

- Labor supply module simulates all the processes taking place in the labor market.

- This module calculates the number of persons by economic activity (employed, unemployed and economically inactive), occupation, field of education, level of education attained, sex, age (annual cohorts).

Labor supply module (implementation)



Labor supply module (mathematical model)

- The basic logic of the model is based on a recursive equation of the form

$$V_{r_0+t+1}^{pl,wk_0+t+1} = (V_{r_0+t}^{pl,wk_0+t})^T M_{pl,wk},$$

where $M_{pl,wk}$ is a transition matrix, and $V_{r_0+t}^{pl,wk_0+t}$, forms a vector describing the size of cohort taking off at year r_0 at age $wk_0 = 15$ and sex pl.

Labor supply module (mathematical model)

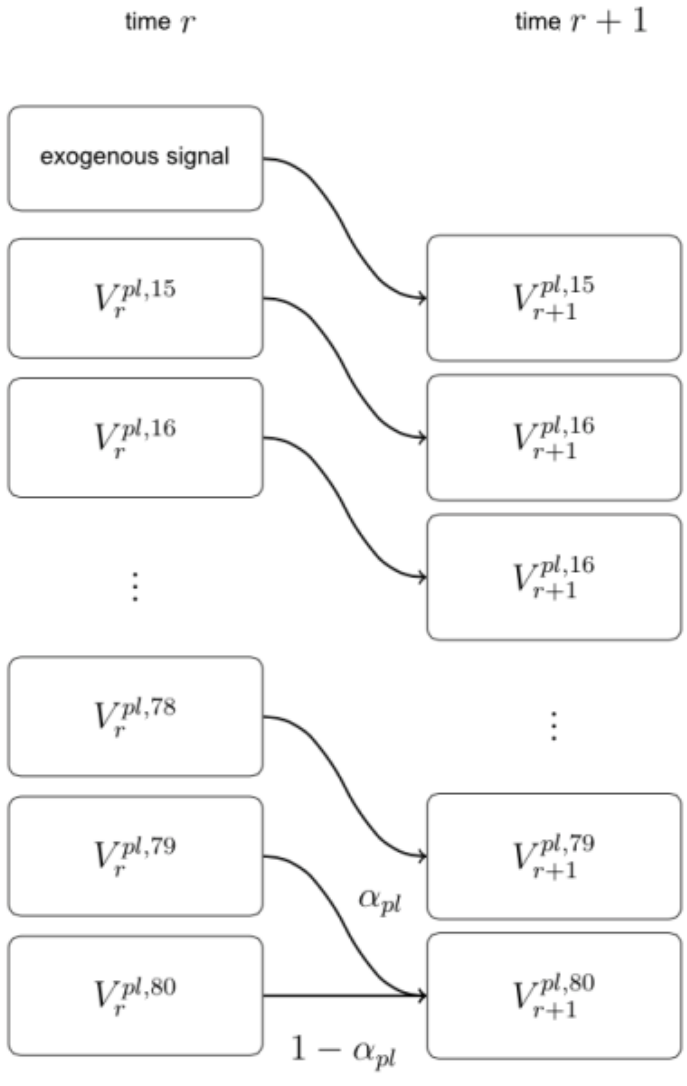
- For age wk = 80 the equation takes the form

$$V_{r+1}^{pl,80} = (1 - \alpha_{pl}) V_r^{pl,80} + \alpha_{pl} (V_r^{pl,79})^T M_{pl,wk},$$

where α_{pl} is the percentage of people (of a particular sex) at the age of 80 in a group of 80+.

Labor supply module (mathematical model)

- Flows between status in the model of labor supply.
- The last status (80+ group) is common for all cohorts.
- The share of historical cohorts decreases exponentially with the parameter $1 - \alpha_{pl}$.

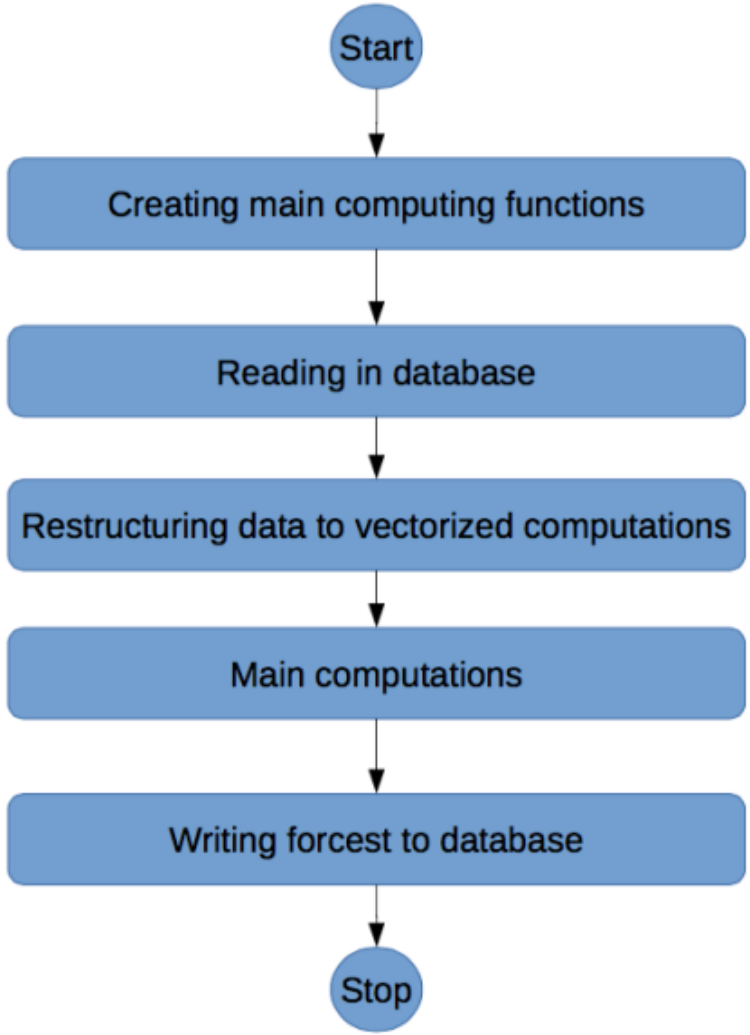


Human capital module (idea)

- The module provides an implementation of dynamics of skills by educational skills (cognitive, noncognitive) and "learning by doing" and their relationship with the level of human capital and investment in educational skills.

- In addition, calculated data takes into account age, educational level and occupational groups.

Human capital module (implementation)



Human capital module (mathematical model)

- Skills are divided at two levels: general skills and specific skills (by educational skills and "learning-by-doing")

- The dynamics of the model is set at the level of specific skills in accordance with the overall equation

$$s_a^{j,i,k} = F_{i,k}(\cdot) + s_{a-1}^{j,i,k} - d(s_{a-1}^{j,i,k}),$$

where F is a function of human capital formation (different for different skills) and d is a function of depreciation.

Human capital module (mathematical model)

- Specific skills are aggregated to the level of general skills using the CES function.

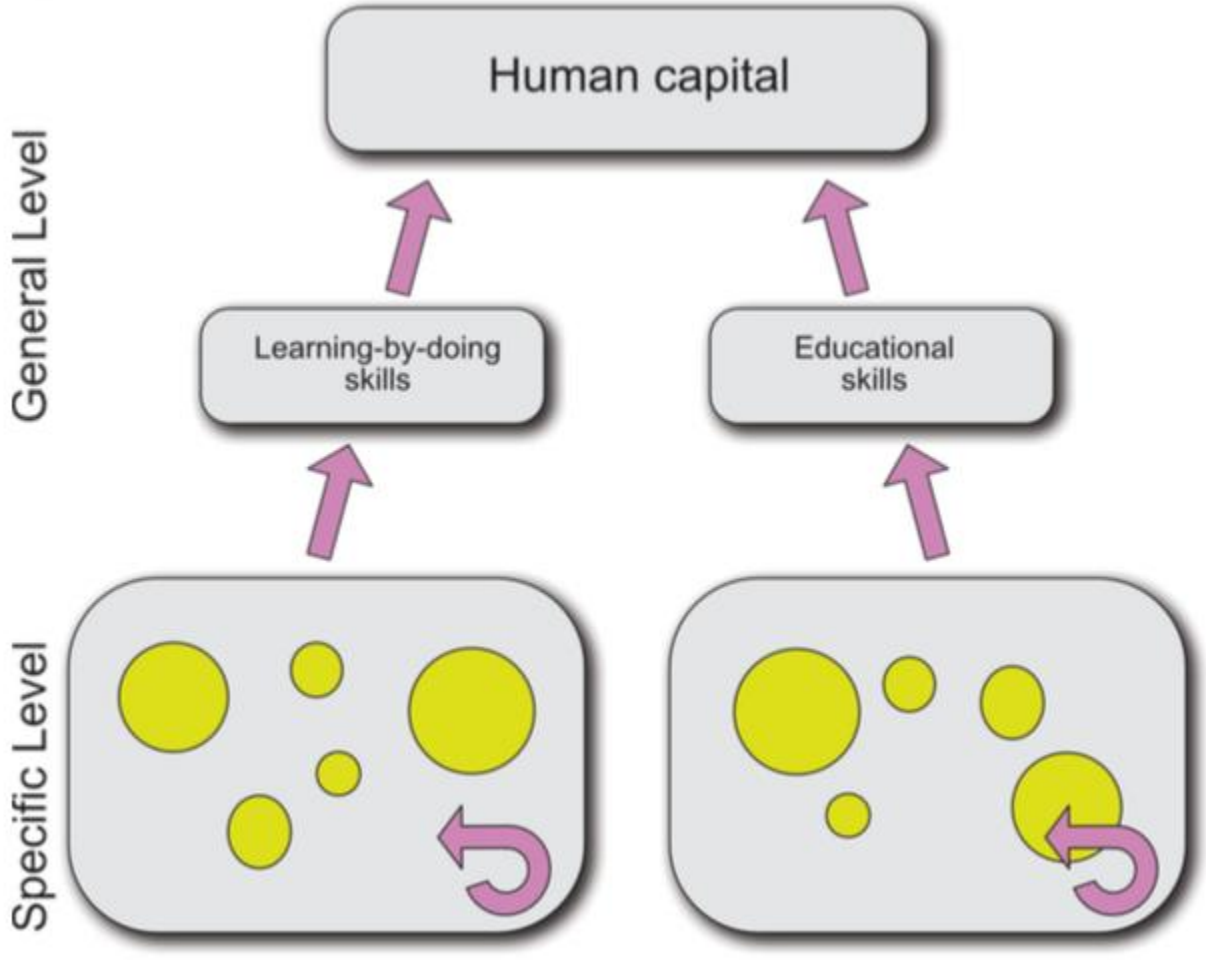
- On the basis of the specific skills human capital is constructed according to the function

$$\omega_a^j = \left(\sum_i \alpha_i (S_a^{j,i})^\sigma \right)^{1/\sigma}.$$

Human capital module (mathematical model)

- Skills are divided into educational skills and learning-by-doing.
- In addition, skills are divided into general skills and specific skills.
- There are two levels of aggregation: from specific skills to general skills and from generic skills to human capital.

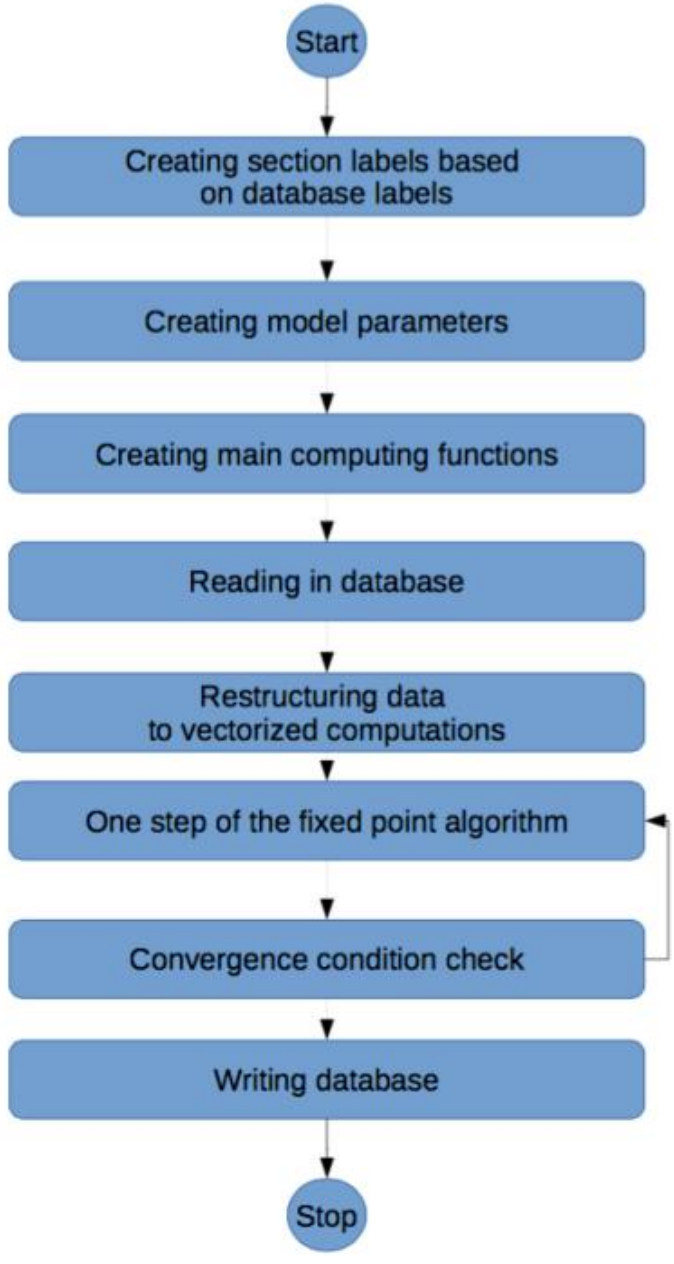
Human capital module (mathematical model)



Wage module (idea)

- Wage module, taking into account the share of innovative subsection, calculates wages and prices in the granulation into innovative subsections and traditional subsections.
- Using set parameters, the module also calculates employment in the same granulation.
- In his module innovative companies and their share in value added are separated.
- Wage module is based on the optimization model.

Wage module (idea and implementation)



Wage module (implementation)

- The basic method of operation of the module is based on the determination of the point of fixed representation of the form

$$w_{\mathbf{i},l,\mathbf{z}} \rightarrow P_{\mathbf{i},l} \rightarrow \mathrm{VA}_{\mathbf{i},l} \rightarrow w_{\mathbf{i},l,\mathbf{z}}$$

where successive transitions are given by the following formulas (resulting from the optimization tasks)

$$P_{\mathbf{i},l} = \frac{1}{{\beta_{\mathbf{i},l}}^{\beta_{\mathbf{i},l}}} \frac{1}{\prod_{\mathbf{z}} {\gamma_{\mathbf{i},l,\mathbf{z}}}^{\gamma_{\mathbf{i},l,\mathbf{z}}}} r^{\beta_{\mathbf{i},l}} \prod_{\mathbf{z}} {w_{\mathbf{i},l,\mathbf{z}}}^{\gamma_{\mathbf{i},l,\mathbf{z}}}$$

$$\frac{\mathrm{VA}_{\mathbf{i},l}}{\mathrm{VA}_{\mathbf{i}}} = \frac{\eta_{\mathbf{i}} \left(\frac{P_{\mathbf{i},l}}{P_{\mathbf{i},T}}\right)^{1-\sigma}}{1 + \eta_{\mathbf{i}} \left(\frac{P_{\mathbf{i},l}}{P_{\mathbf{i},T}}\right)^{1-\sigma}}$$

$$\frac{\sum_{\mathbf{i} \in S(i), \mathbf{z} \in S(z), l} \gamma_{\mathbf{i},l,\mathbf{z}} \mathrm{VA}_{\mathbf{i},l}}{H_{i,z} L_{i,z}} = w_{i,z}$$

Data sources

- Individual data
  - Labour Force Survey (LFS)
  - Programme for the International Assessment of Adult Competencies (PIAAC)
  - Structure of Earnings Survey (SES)

- Aggregated data
  - CSO (GUS)
  - EUROSTAT
  - OECD
  - IMF

„Simulation-prognostic structural model of the Polish economy taking into account the phenomena associated with human capital”

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