Preconditions of Latvian Labour Market Forecasting and Policy Analysis System Dynamics Model Development

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Abstract
This paper shows the preconditions of the labour market forecasting and policy analysis system dynamics model development in Latvia. Labour market planning is topical in any country. The novelty element of the paper relates with the practical application of the system dynamics method for the state needs in Latvia for labour market forecasting as well as with development of a one of the most powerful models of labour market forecasting in the World. In the paper the system dynamics experience in labour market forecasting and the international practice in labour market forecasting are investigated; the structure of the model and its several components, as well as the possibilities of the model and the forecast of the most important parameters of labour market in Latvia are shown.

Keywords: system dynamics; labour demand; population; migration; employment; unemployment; working places; forecasting; education policy analyse.

Introduction

Labour market planning is topical in any country. For Latvia topicality of the problem is stressed by the new conditions: after entering the European Union (EU) Latvia faced new possibilities in international labour market. The EU member states have opened their labour markets to workers from Latvia. The largest amount of labour force moved to Ireland, Great Britain and Sweden. The migration process has a significant influence on the labour market in Latvia. These processes will also influence the future development of Latvia; therefore the research of these issues is of high importance for Latvia. It is also important internationally, because in other countries, especially in the new EU member states, the similar processes take place.

In the paper the researched problem is related to labour market planning and forecasting model development and use.

The novelty element of the research relates with the practical application of the system dynamics method for the state needs in Latvia for labour market forecasting as well as with development of a one of the most powerful model of labour market forecasting in the World.

The object of the research is preconditions of labour market forecasting and the development of the policy analysis system dynamics model.

The aim of the paper is to investigate the circumstances of the development of the labour market forecasting system dynamics model.

To achieve this aim, the following tasks are set:

- ✓ to study system dynamics experience in labour market forecasting;
- ✓ to study international practice in labour market forecasting;

- ✓ to show structure of the model and its several components;
- ✓ to show possibilities of the model;
- ✓ to forecast the most important parameters of labour market in Latvia.

The study shall use both traditional mathematical, statistical, economic and econometric analysis methods, such as time-series trends, regression method, but the principal method of the research is the system dynamics method.

The information base of the study is the unpublished information of the Central Statistical Bureau of the Republic of Latvia.

Methodological basis of the research is based on the works of the system dynamic top scientists: Forrester J., Dale Runge, Petrides L., Dangerfield B., Bo Hu, Hans-Rolf Vetter, Torres D.S., Lechon R.F., Vizayakumar K., Winch G., Skraba An., Arthur D., Moizer J., Mutuc J. and so on.

The research results have been tested and would to be be implemented after 2013 by the Ministry of Economics of the Republic of Latvia, as well as by other state institutions.

In preparation of this article is used technical documentation of the Latvian labour market medium and long-term forecasting and policy analysis model (published in Latvian: Latvijas darba tirgus vidēja un ilgtermiņa prognozēšanas un politikas analīzes modeļa tehniskā dokumentācija).

System dynamics experience in labour market forecasting

The aim of the section is to investigate the system dynamic method experience in the labour market forecasting, to find and investigate the best and the classical models and algorithms for a new labour market forecasting model.

Human resource planning is the process of analysing an organisation's human resource needs under changing conditions and developing the activities necessary to satisfy these needs in a timely, accurate and professional fashion. In practice, human resource planning is related to labour supply and demand, and problems arising from the process of aligning these factors. There are several steps that must be included in any comprehensive workforce planning effort:

- analysing the present workload, workforce, and competencies;
- identifying the workload, workforce, and competencies needed for the future;
- comparing the present workload, workforce, and competencies to future needs to identify gaps and surpluses;
- preparing and implementing the plans to build the workforce needed for the future.
- evaluating the success of the workforce planning model to ensure that it remains valid and objective.

Traditionally, in the world for human resource planning more widely available methods are applied: time series analysis, econometric methods and so on. On this basis, many forecasting models are developed, e.g., Tichy un Devanna model, Harvard model, Walker model, Markov model, Holonic model (cross-table model). In table 1 they are compared with the system dynamics method.

Table 1

Comparison of the classical and the system dynamics labour resources forecasting models

(Adapted from Izidean Aburawi and Khalid Hafeez)

Benchmarking Characteristic	Tichy and Devanna model	Harvard model	Walker model	Markov model	Holonic model	System dynamics method
Training and recruitment	-	*	**	**	**	**
Forecasting human resource needs	**	-	**	**	**	**
External conditions	*	*	**	**	**	**
Human resource Flow	-	**	*	*	*	**
Promotion	**	**	*	**	**	**
Staff turnover	**	-	*	**	**	**
Human resource development	**	*	**	-	-	*
Hiring and Firing	-	*	**	**	**	**
Complexity	-	-	*	**	*	*
Feedback	-	*	-	-	-	**
Forward planning	*	-	*	**	**	**
Ease of understanding and use	*	-	-	*	**	**
Controllability and optimisation	-	-	-	*	*	**

Where: - not addressed; * addressed; ** addressed very well.

In spite of the system dynamics method and model advantages, it is not widespread and is not used for public & states purposes. This is due to the “late start” of the system dynamics method. In comparison, the classical models have been developed for 5-10 years earlier than the first solution (computer program) based on the system dynamics principles appeared in market. Without it system dynamics was just a theoretical concept or additional instrument for thinking. Ten years period is long enough to go very far, take up the space in researchers heads, to prove capabilities, to reflect the benefits. The future development of system dynamics is related to the change of generations and the failure of traditional methods in times of crisis. In stable conditions, the classical models do a forecast a few percent better than system dynamics models, however, they are unable to forecast the trend changes, what system dynamics allows. Today the time has come on practical research base system dynamics must have a predominant role in the labour market forecasting. System dynamics models facilitate decision-making opportunities, as well as develop medium and long-term strategies for effective human resource planning. There are already plenty of developed models, which are discussed in this chapter.

Labour analysis, planning is inextricably related to the population, because the labour force is a part of the population. The first system dynamics population model was developed by Jay Forrester. The classical system dynamics population forecasting model is shown at Fig. 1.

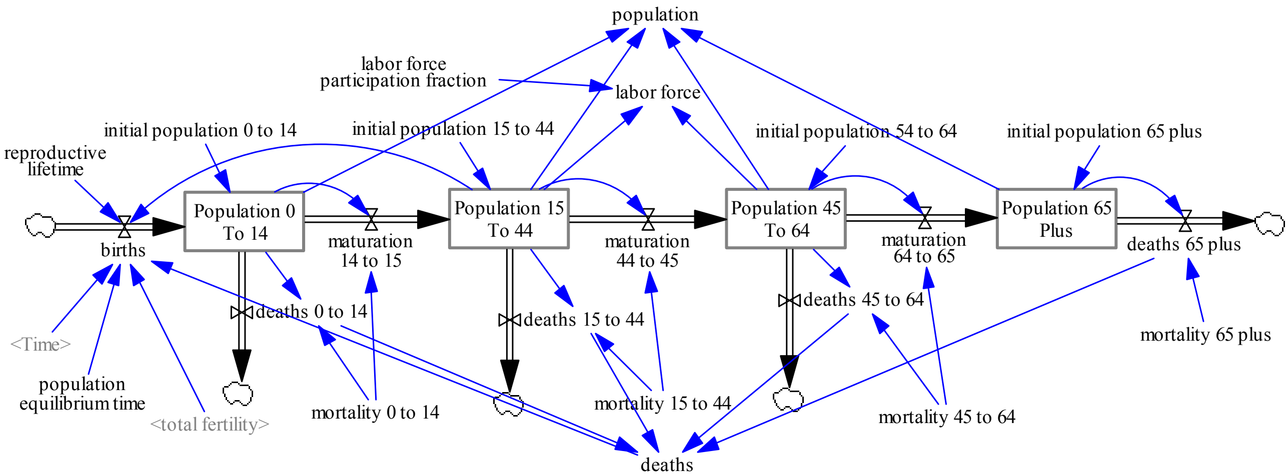

Fig. 1 The **classical system dynamics population forecasting model** (adapted from World3 population sector)

The classical system dynamics population forecasting model reflects the flow of people from birth, childhood, child-bearing age, working age to retirement age and death. In any given period, it is possible to trace the individual population of each set of socio-economic composition, its age, etc. This model is used by almost every population and labour-related system dynamics study.

At system dynamics developing stage, one of the first models was directly connected to the labour market models. For example, in the 1976th such models develop Dale Runge. Today, these models have become a classic, but the different elements of them are still used, for example, the division of the labour market on separates sectors (Fig. 2 and 3).

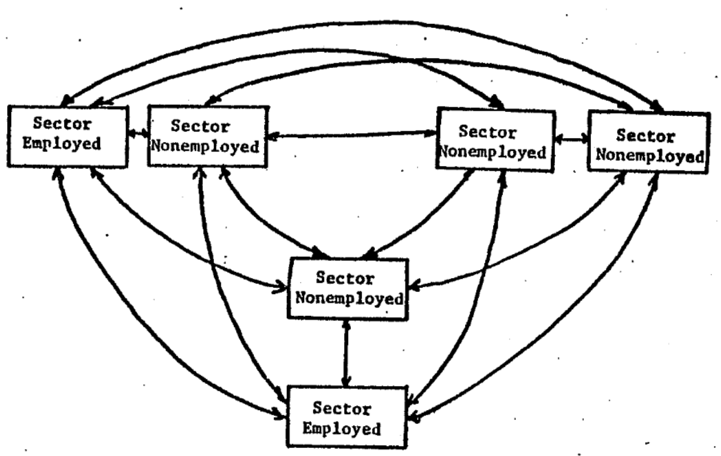

Fig. 2 **Potential multi-sector employees flow** (Dale Runge, 1976).

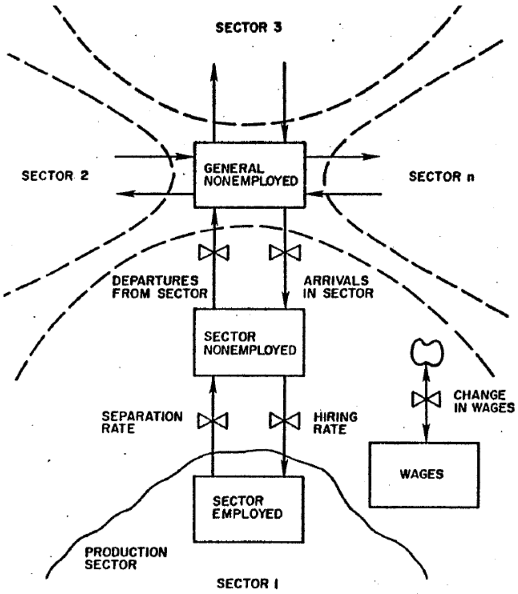

Fig. 3 **Labour market multi-sector model structure** (Dale Runge, 1976).

Analysing the classical models, it is evident that together with the number of employees in models such important factors as salary, sector specific (manufacturing sector) have been analysed. Later models have been developed reflecting industry, the services sector (Fig. 4 and 5) according to the specific sectors: agriculture, education, high-tech sectors (Fig. 6) and so on.

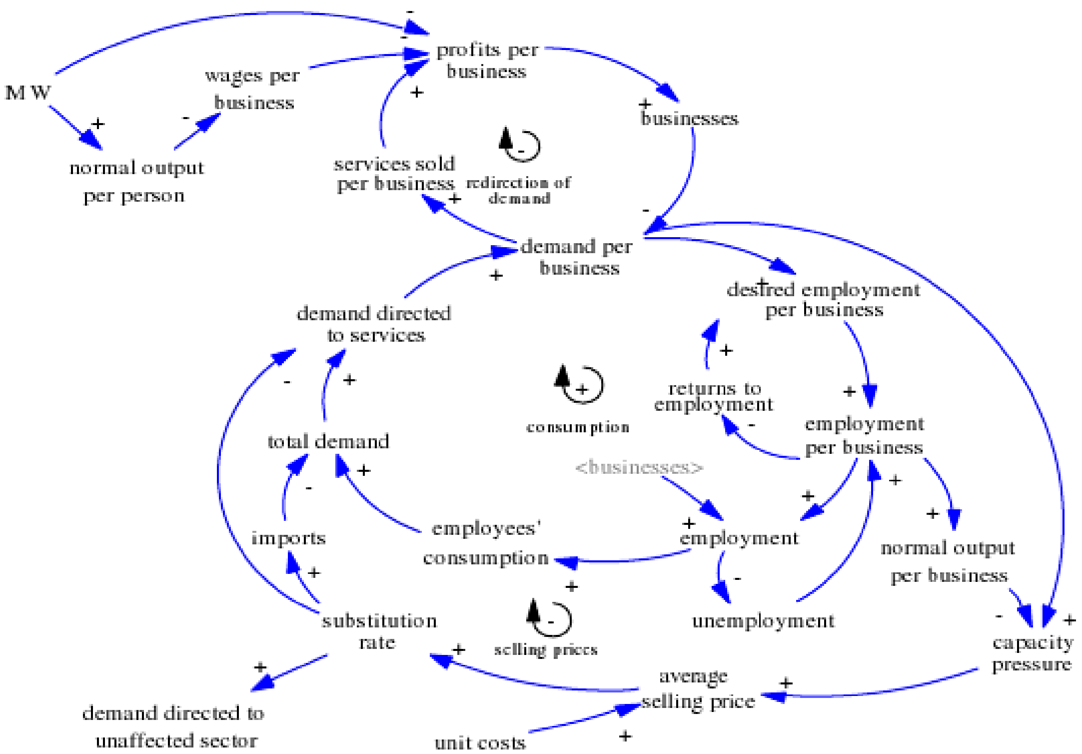

Fig. 4 **Labour market services sector model structure** (Petrides L; Dangerfield B., 2002).

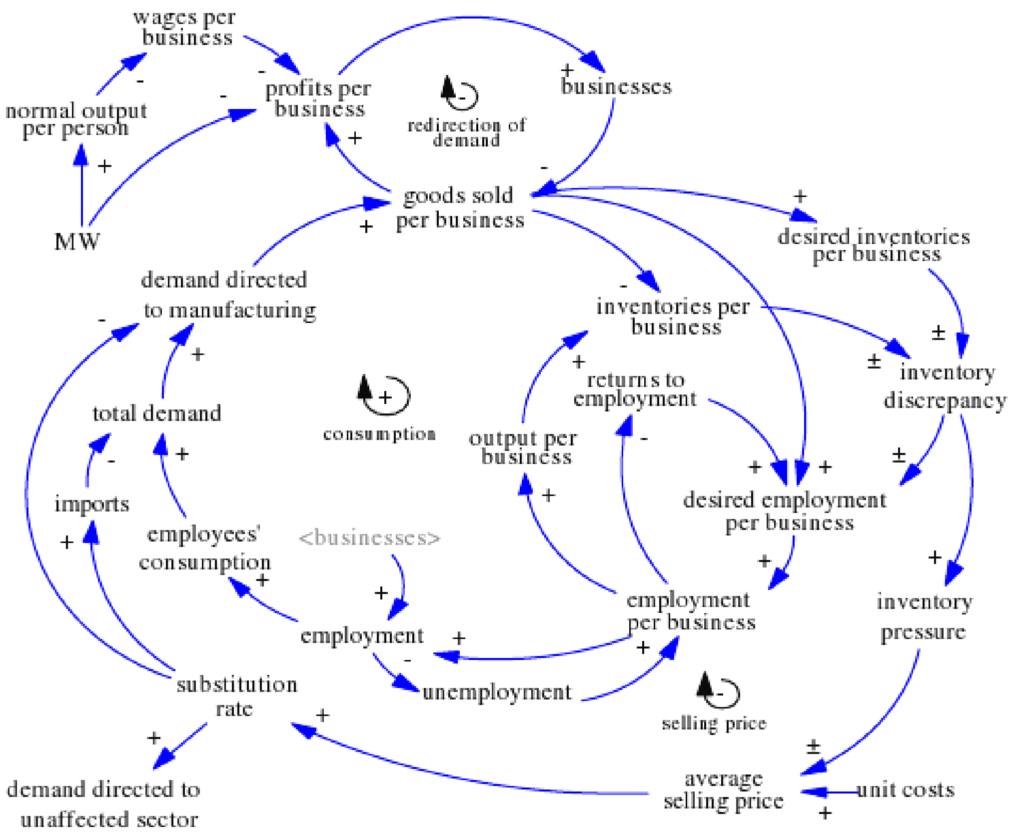

Fig. 5 **Labour market manufacturing sector model structure** (Petrides L; Dangerfield B., 2002).

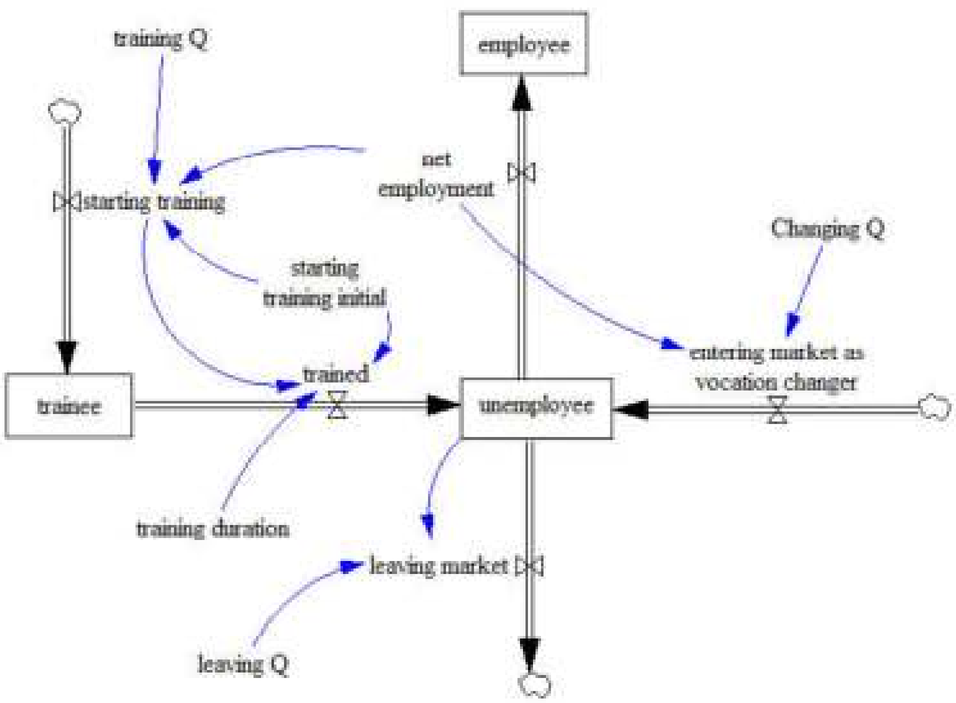

Fig. 6 **Labour market IT sector model structure** (Bo Hu; Hans-Rolf Vetter, 2008).

Fig. 3 shows that the structure of the labour market model is not unique; Fig. 7 shows an alternative model.

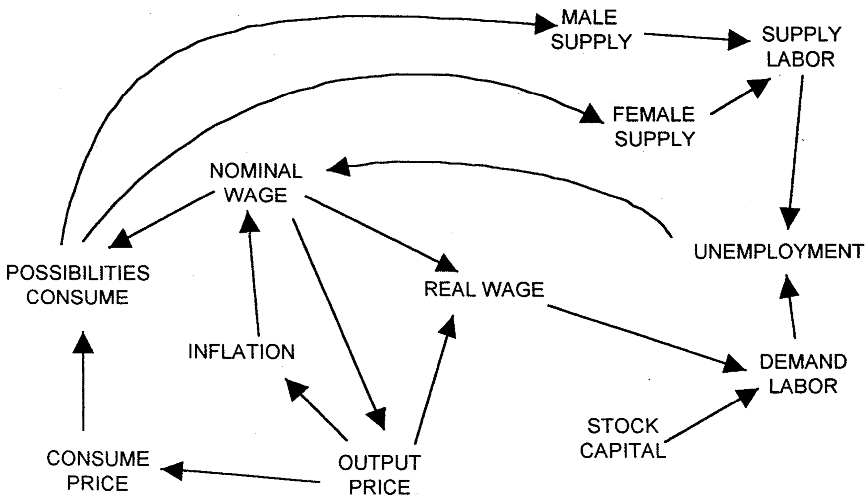

Fig. 7 **Labour market model relation to key economic indicators** (Torres D.S.; Lechon R.F., 1995).

The alternative model's advantage is not only in relation with the economic indicators, but also in the distribution of the population by gender, which is reflected in Fig. 8.

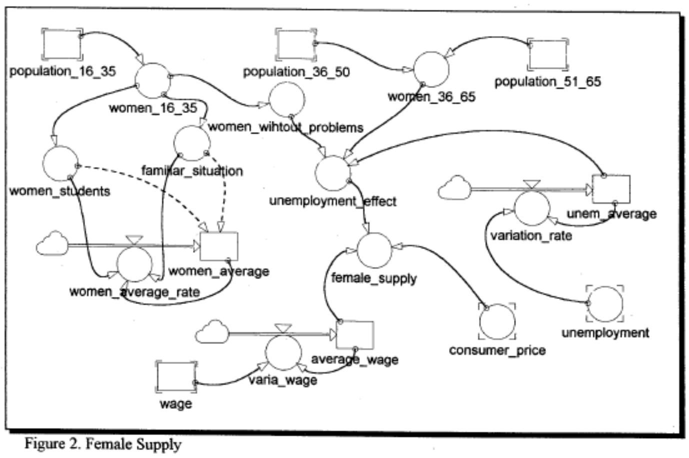

Figure 2. Female Supply

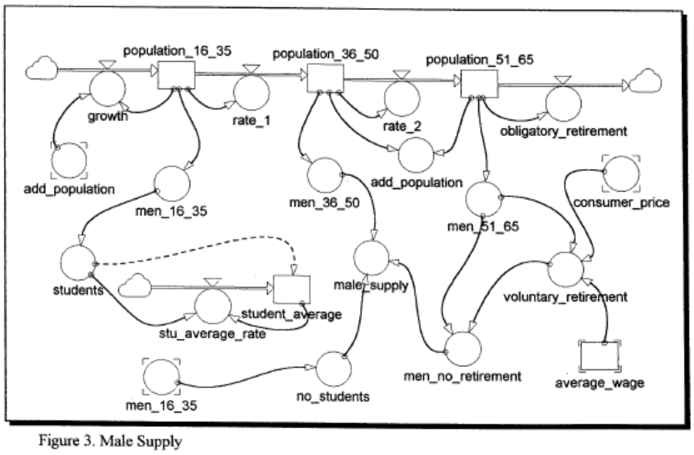

Figure 3. Male Supply

Fig. 8 **Labour supply by gender** (Torres D.S.; Lechon R.F., 1995).

Each of the developed models has its own specificities. Fig. 9 reflects the model which not only focuses on labour supply and demand balance, but also indicates a skill forming block.

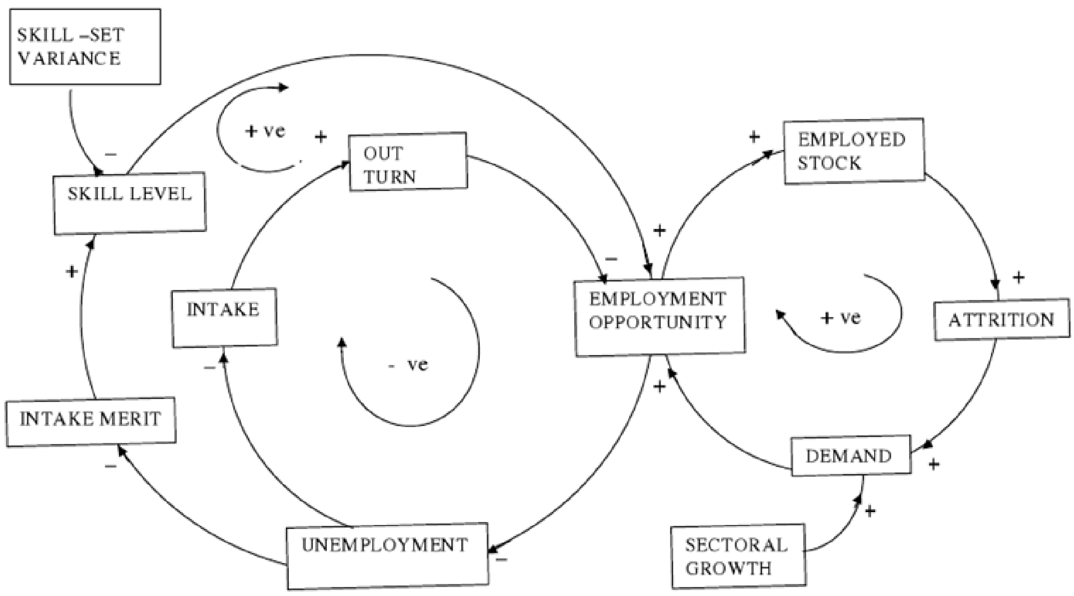

Fig. 9 **Labour supply and demand balancing** (Vizayakumar K., 2005).

Labour skills, skills and education formation are important components of the labour market. The examples of the models reflecting these components are shown in Fig. 10, 11 and 12.

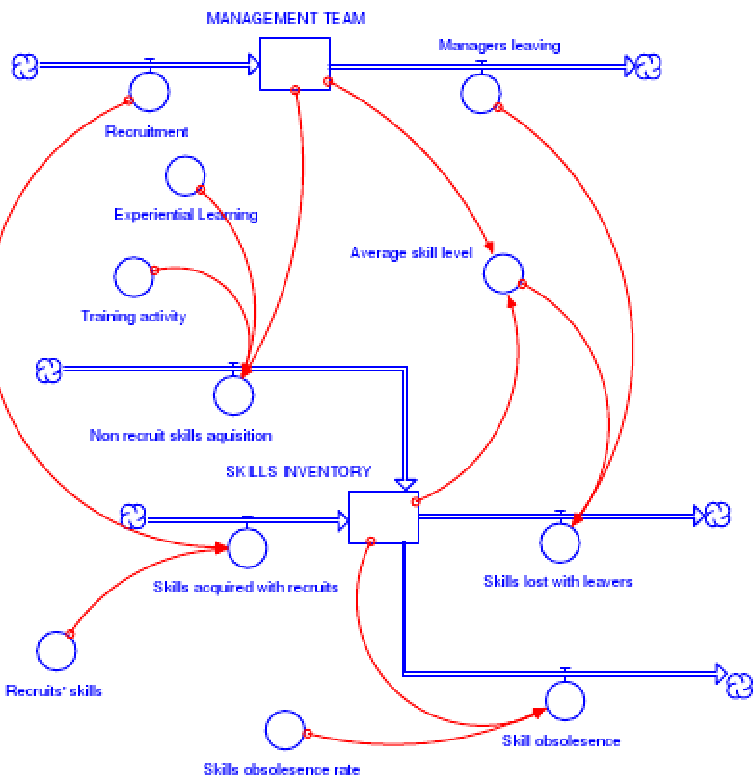

Fig. 10 **Skills analysis model** (Winch G., 1998).

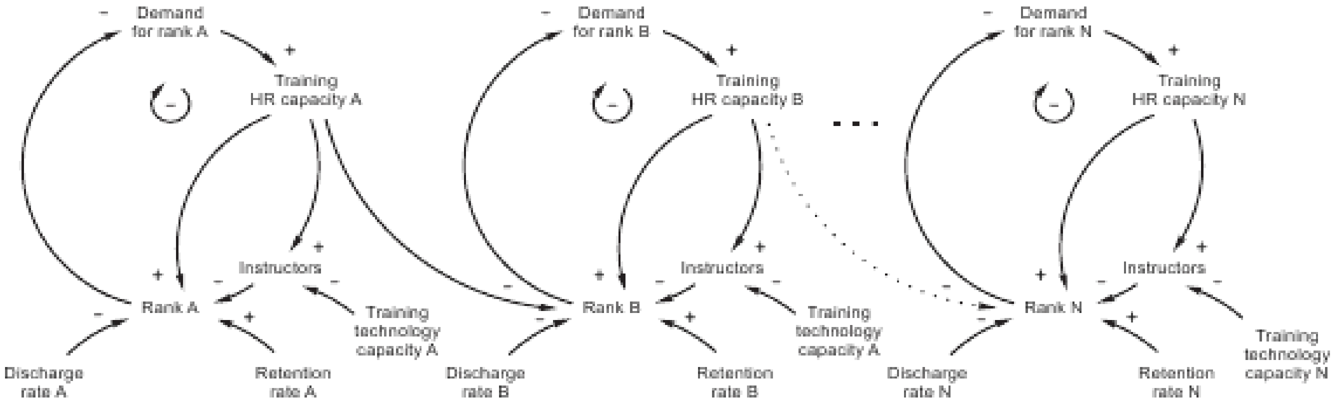

Fig. 11 **Professional grow model** (Skraba An.; et al, 2007).

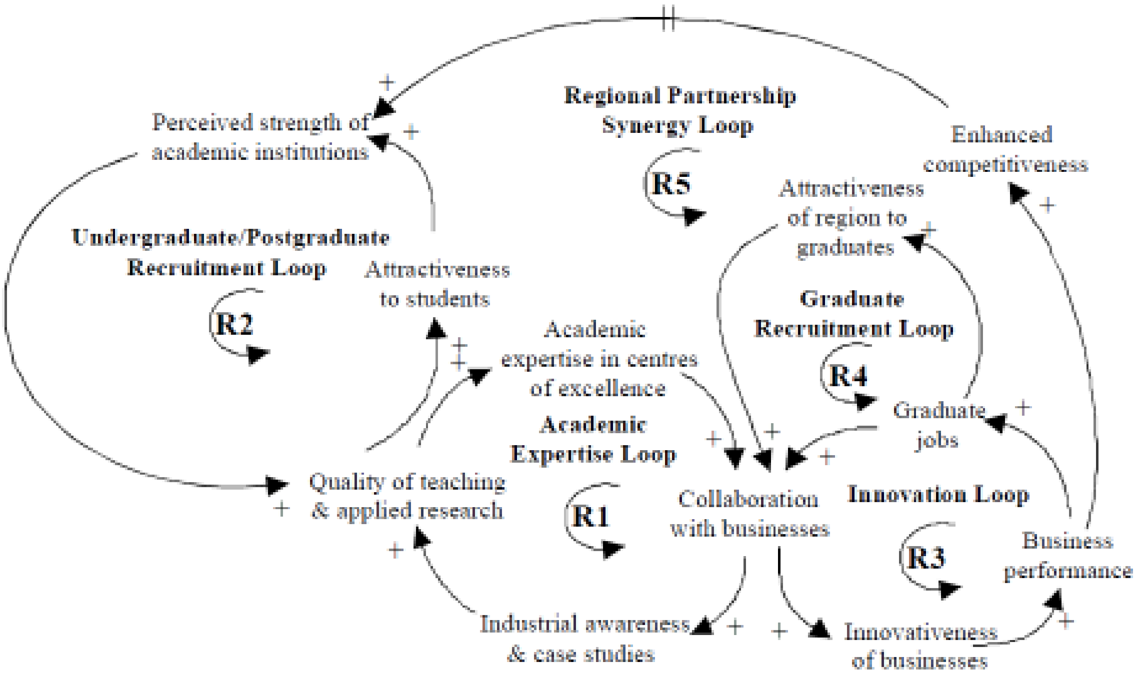

Fig. 12 **Education and business cross-exposure model** (Arthur D.; Moizer J., 2000).

It is possible to find alternatives for each of the reflected models. For example, Fig. 11 shows theoretical professional grow, but its practical realization by other authors can be seen in Fig. 13.

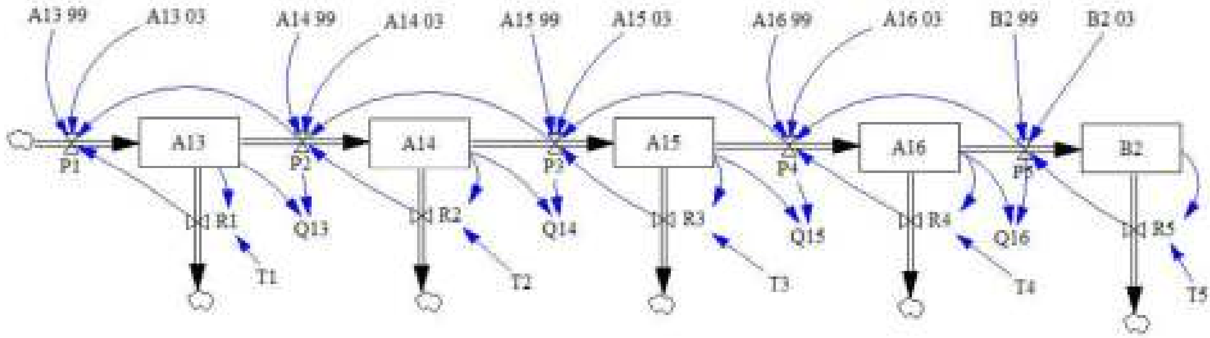

Fig. 13 **Career model** (Bo Hu; Hans-Rolf Vetter, 2008).

Labour supply is connected not only with the number of people and people's structure (education, skills, experience) but also with wishes to participate in the labour market, see Fig. 14.

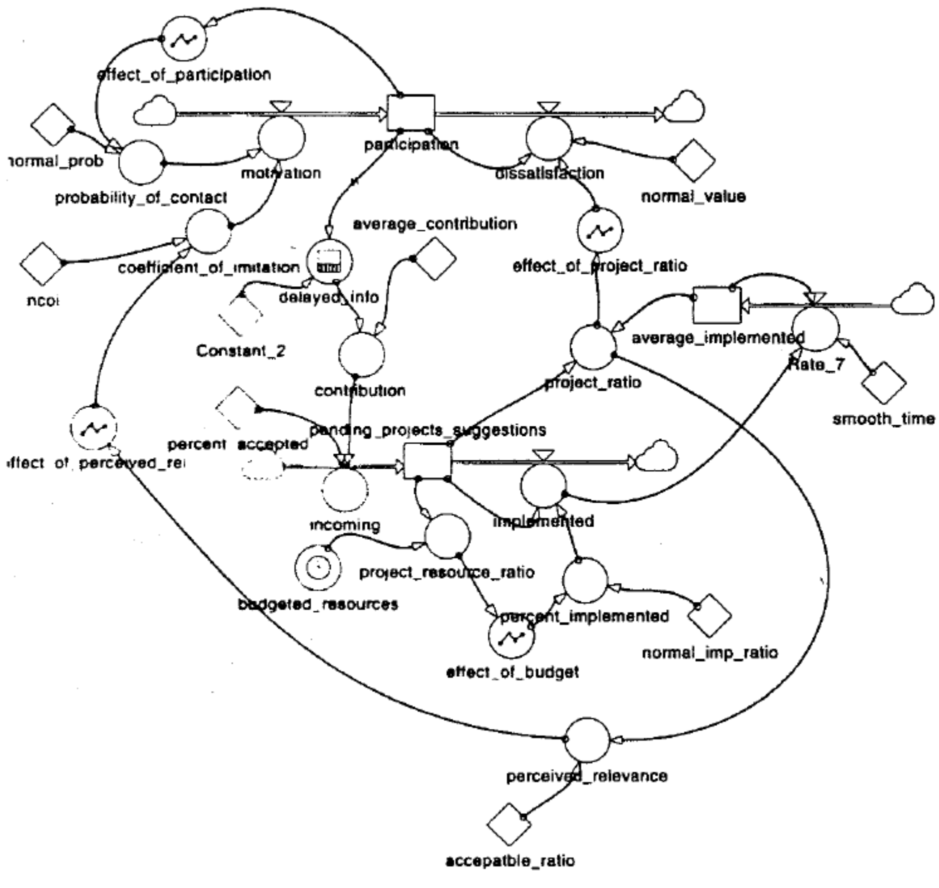

Fig. 14 **Labour motivation and participation model** (Mutuc J., 1994).

Images above (Fig. 1 to 14) shown the schemes for the model of supply module. This allows realization of simulation of population, education, economic activity. The specific feature of Latvia is a big proportion of international labour migration. Due to this, the best model of labour migration has been developed for the Latvian conditions, see Fig. 15.

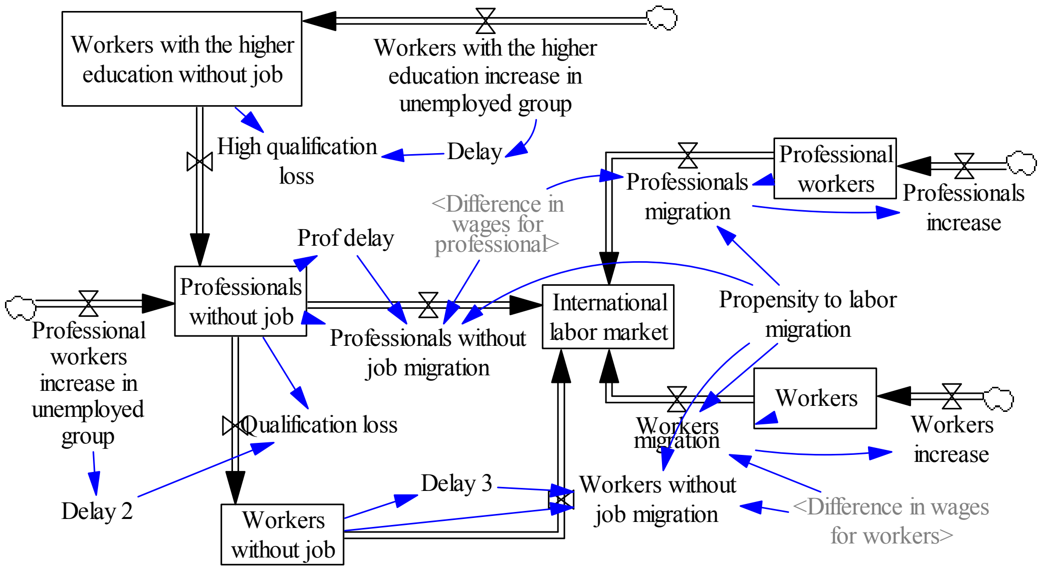

Fig. 15 **Labour migration model** (Skribans, 2009b).

Fig. 15 demonstrates the last labour supply module block. The next block is related to the demand module. The key elements of the labour demand module are shown in Fig. 16.

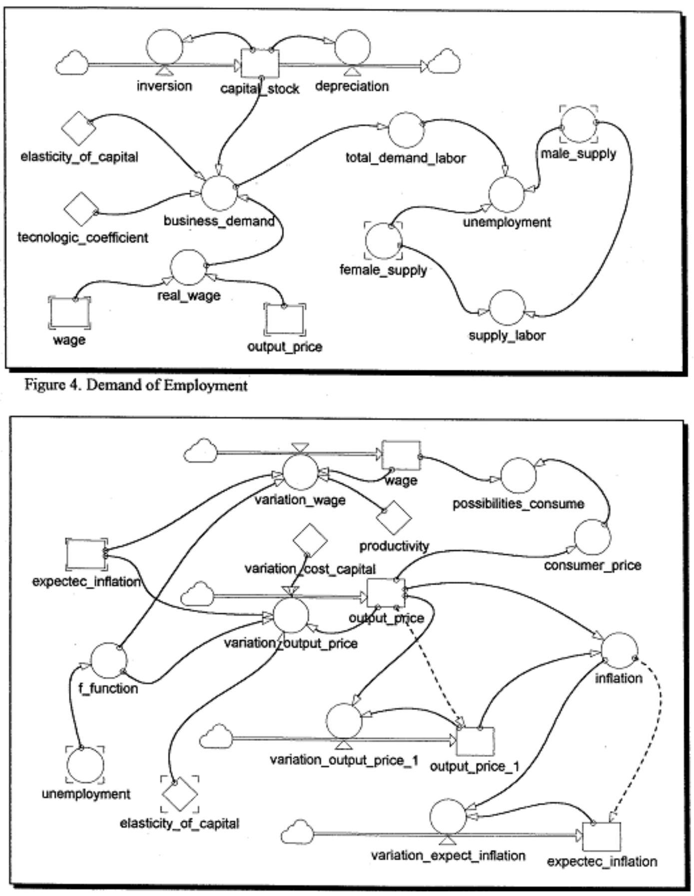

Fig. 16 **Labour demand and wage formation** (Torres D.S.; Lechon R.F., 1995).

Fig. 16 presents the labour demand and wage formation model. The labour demand model describes not only demand, but also demonstrates inter-related elements, including employment and unemployment. The wages block is important because it determines the motivation for education, employment careers, i.e. defines the offer, which regulates demand.

The section conclusion. The analysis of the system dynamics method application for the labour market forecasting demonstrates that the selected method corresponds to the object. There are many models developed, that could forecast labour market. It is possible to use the previous system dynamics practise for the development of a new model, by combining best solutions from the already existing models.

Research methodology

Structure of the model

Based on literature review and previously developed models analysis, author take decision to adapt best of mentioned models and its components for Latvia. First of all, the structure of the new model was developed, see Fig. 17.

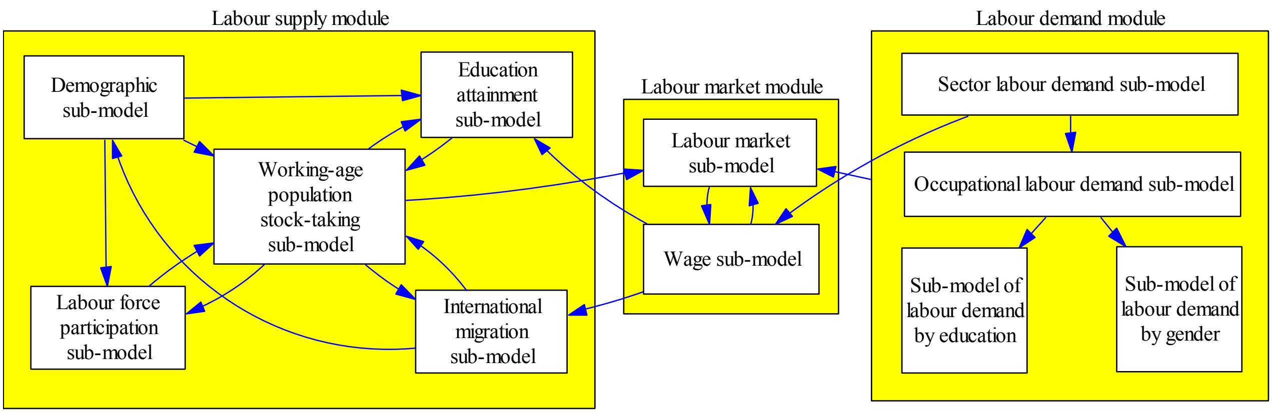

Fig. 17 **Logic structure of the model**

As the Fig. 17 shows, the model involves three modules - labour supply, demand, and market modules.

Labour demand module simulates the labour productivity, labour demand by fields and levels of education, occupations and gender. Labour demand module consists of sector, occupation, education and gender labour demand sub-models.

Sector labour demand sub-model determines the labour productivity and labour demand by sectors on the basis on GDP forecasts.

The labour demand by occupations (in the sub-model of the labour occupational demand) is being calculated on the basis of the sector labour demand.

The labour occupational demand sub-model provides the calculation of the labour demand by levels and fields of education (in the sub-model of the labour education demand), as well as labour demand by gender (in the sub-model of the labour gender demand).

Labour supply module simulates the demographic processes, division of the population by age, gender, economic activity, education and occupation. Labour supply module consists of demographic, education attainment, working-age population stock-taking, labour force participation and international migration sub-models.

Demographic sub-model defines population by age groups and genders. This sub-model defines the population fertility, mortality and aging. When the population reaches the 7-year-age, the demographic sub-model defines the number of incoming in the education system population. When the population reaches the working age, demographic sub-model defines the growth of the labour force (in the working-age population stock-taking sub-model), in accordance with previous education (education attainment sub-model) and the estimated economic activity. When the population reaches the retirement age, demographic sub-model defines the decline in labour. The same happens in case of death before the retirement age.

Working-age population stock-taking sub-model represents the labour structure by 5-year age groups, genders, economic activity, education and professional occupations, that is, reflects the operating results of other sub-models.

Labour force participation sub-model defines the labour structure in the field of economic activity.

Education attainment sub-model defines not only the increase of the primary labour amount (along with demographic sub-model), but also the changes of the labour structure along with education attainment, including lifelong education system.

International migration sub-model defines the change of population and labour along with the international migration processes.

Labour market module simulates employment, unemployment, working positions, unoccupied vacancies and wages. Labour balancing module consists of two sub-models: labour market and wage sub-models.

Labour market sub-model combines supply and demand, taking into account the working positions, unoccupied vacancies, the amount of labour and wages.

Wage sub-model analyses the most important processes in the national economy (change of productivity) and labour demand and supply amounts, forming the labour salaries. Labour salaries affect both labour market balance and labour supply formation, that is, affect the choice of education and international migration.

Components of the model

The developed model has a relatively complex structure and the relations of its elements; therefore this article describes only several components of the whole model.

The first described component is **labour demand sub-model**. The sub-model is based on Leontief production function, and GDP and employment in the base period, as well as the production function coefficient (productivity index) have been used in the calculations. Sub-model logical structure is represented in the Fig.18.

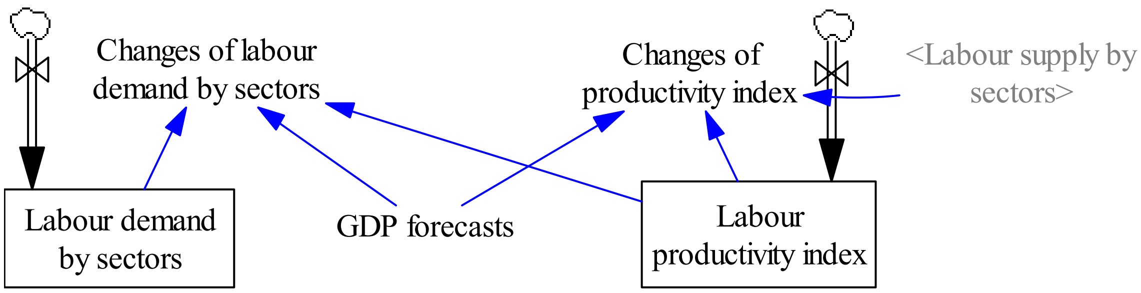

Fig. 18. **Logical structure of the labour demand sub-model of national economy sectors**

Fig. 18 represents in a simplified form that the labour demand by sectors is calculated on the basis of GDP forecasts and labour productivity index. Also, the labour productivity index is calculated from GDP forecasting and labour supply by sectors (from the labour supply module), which is necessary in order to ensure the forecasted GDP at the existing labour volume. Labour demand calculation is discussed in detail below, but the calculation logic of the productivity index is represented in the Fig. 19.

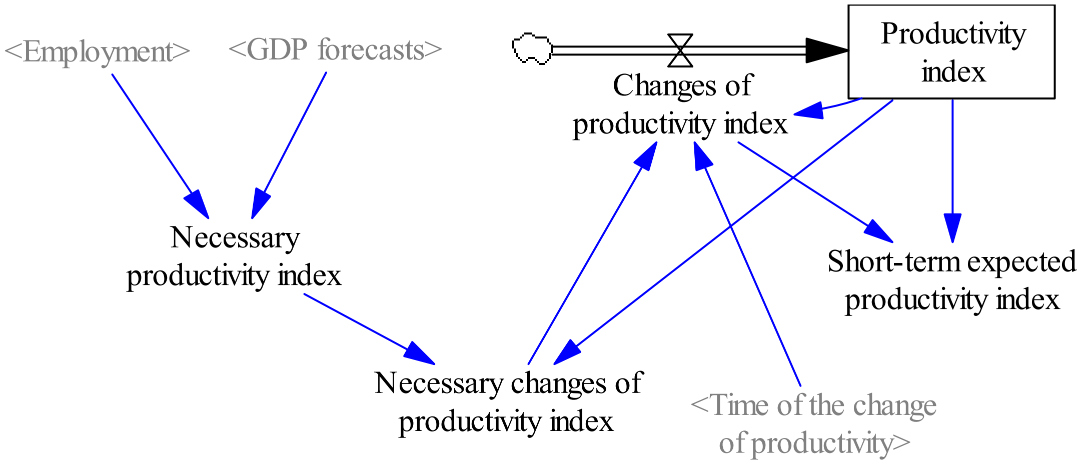

Fig. 19. **Calculation of productivity index**

The necessary labour productivity index is being calculated from GDP forecasts and current employment rate. The index represents the value of the productivity coefficient (Leontief production function) in order to ensure the certain GDP volume at the existing level of employment. Comparing the required productivity index with the actual productivity index, it is possible to determine the changes in capacity, labour productivity (in the model - productivity index) that are necessary to ensure in economics the forecasted GDP, the difference is reflected in the index "necessary changes of productivity index" (the principle that the economy is being developed due to the increasing productivity rather than the employment growth). Productivity cannot be changed immediately, as soon as the need arises. The change of actual productivity index is going slower than the change of required productivity index, as the delay is being affected by the time of productivity changes. Short-term expected productivity index is being used while planning the labour demand for the future period (short-term expected productivity index changes in the current period, while productivity index - only in the future period).

Calculation logics of the labour demand forecast is presented in the Fig. 20.

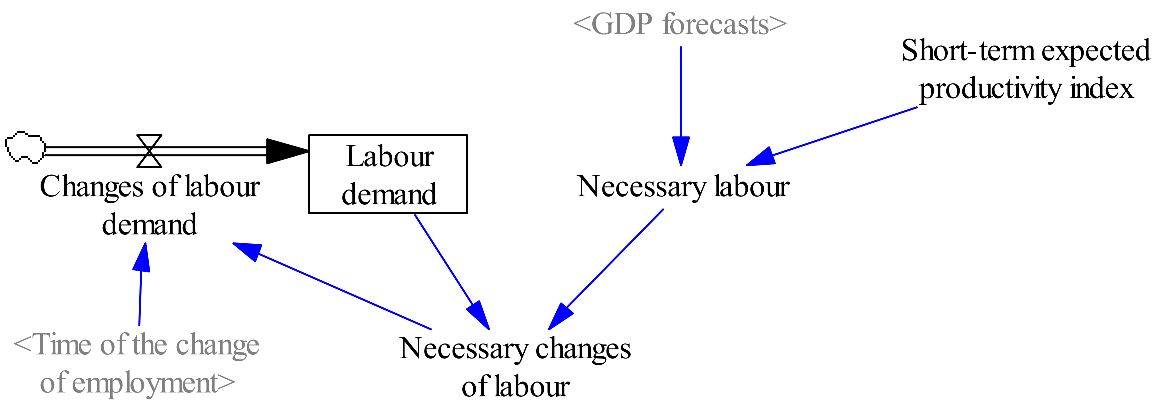

Fig. 20. **Calculation of labour demand**

Fig. 20 reflects the calculation logics of labour demand. The necessary labour has been determined from the GDP forecasts and short-term expected productivity index values. The index “necessary labour” reflects which should be employment (number of employed persons) in order to ensure the certain GDP volume at the given level of productivity (productivity index in the Leontief production function). The changes of labour are calculated from the required labour - the difference between the required and existing labour. Then the changes of labour are calculated in accordance with the time of employment changes and labour.

The developed model is very big, its description can take over 250 pages, so, take into account article format, there is shown one more element of the model. It is the **labour demand and supply balancing module**, its overall scheme is presented in Fig. 21.

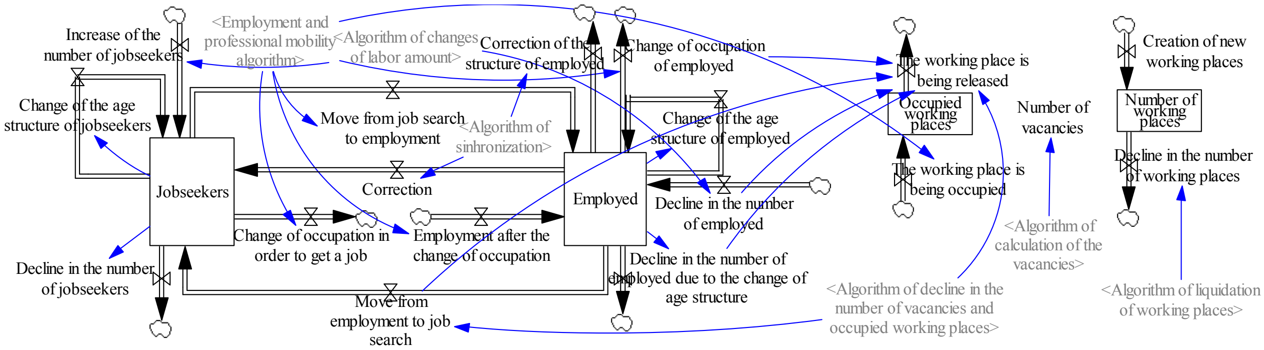

Fig. 21. **Scheme of the algorithm of the labour market sub-model**

Fig. 21 presents the labour market sub-model stocks, flows, key elements and algorithms scheme. The Fig. 21 reflects all stocks and flows, the impact of the algorithm on them, but it is not presenting the impact of the stocks and flows on key elements of the algorithms in detail. The Fig. 21 provides presentation of the logic operation and stock - flow system of the module.

The stock of number of jobseekers, i.e., the number of jobseeker is being calculated by adding the increase of the number of jobseekers to the initial number of jobseekers (this flow can be positive, i.e., may reflect the direct increase, and can also be negative, indicating the labour reduction), as well as adding the unemployed persons, who move from employment to job search (i.e., employees who lost their jobs), and subtracting the unemployed persons, who move from job search to employment (have found job), subtracting the decline in the number of unemployed persons, who change occupations in order to receive a job (have found a job in another occupation), subtracting the decline in number of unemployed persons due to aging, as well as changing the age structure of the jobseekers and making the correction of the jobseekers in accordance with the synchronization algorithm.

The stock of the number of jobseekers with three flows (move from job search to employment, move from employment to job search and correction) is directly related to the stock of the number of employed.

The stock of the number of employed, i.e. the number of employed is being calculated by adding the unemployed persons, who move from job search to employment (have found job) to the initial number of employed, adding the persons who found a job after the change of occupation, adding the decline in number of employed (this flow can be positive, i.e., may reflect the direct increase, and can also be negative, indicating the labour reduction), and subtracting the number of employed, who changed their occupations (on the one hand, this flow subtracts the number of employed, who changed their occupations from the stock of the number of employed, while, on the other hand, adding the number of employed with new occupations, thus, the flow in some groups may be both positive and negative), subtracting the decline in number of unemployed persons due to aging, as well as changing the age structure of the jobseekers and making the correction of the jobseekers in accordance with the synchronization algorithm.

In total, stocks of the number of jobseekers and employed and the binding flows are modelling the labour (active population) movement in the labour market: transition from employment to job search and backward, the changes of occupational and age structure, as well as labour growth and reduction.

Fig. 21 presents the other stocks, namely the occupied working places and the number of working places. The stock of the number of working places is reflecting in the national economy the number of the proposed working places, but the stock of the occupied working places reflects how many working places are being occupied. Occupied working places are resulting from the initially occupied working places and affecting changes, i.e., release, occupation and correction of occupied working places (appropriate flows). Working places are resulting from the initial working places and affecting changes, i.e., creation and liquidation of working places (appropriate flows).

All flows presented in Fig. 21 are interrelated. Algorithms presented in Fig. 21 ensure synchronization of the flows. Employment depends on two factors: labour supply and demand, or, in other words, working places and labour (employed and jobseekers). By synchronizing working places, occupied working places and the number of employed, the biggest problem is related to the fact that the certain working places can be occupied by partially appropriate staff, that is, for example, the working place can be occupied by the employee with the appropriate occupation, but with nonconforming gender and education. In this case, the structures of working places, occupied working places and employed do not match. The number of vacancies cannot be calculated by subtracting the number of occupied working places from the number of working places. There is a need to include the corrections and synchronization algorithms.

The flows in Fig. 21 present the results of the algorithms, which combine sub-model algorithms with the most important (central) model parameters. The input data for the flows in Fig. 21 are mostly related to the sub-model algorithms. Unfortunately, article pages limit don't allow explain all algorithms, sub-models and modules of the model.

Section conclusion. Model development experience shows that with method use it is possible to develop labour market forecasting and policy analysis model meeting the highest requirements.

Model results

The model provides the forecasts of the following parameters:

- *labour demand* in terms of economic sectors (NACE 2), gender, skill groups (adapted according to the ISCO-08; 3-digit occupation code level; 127 occupational group units), levels (adapted according to the ISCED97; 8 units) and fields (adapted according to the ISCED97; 79 fields) of education;
- *population*, including the population long-term international migration, in terms of gender, 1-year age groups; 5-year age groups, gender, skill groups, levels and fields of education;
- *economically active population* in terms of gender, 5-year age groups, skill groups, levels and fields of education;
- *the number of employed population* in terms of 5-year age groups, skill groups, levels and fields of education and economic sectors;
- *the number of unemployed* in 5-year age groups, skills groups, levels of education and sectors of the economy;

- *the number of working places*, including free vacancies according to the requirements to gender, profession, level and field of education determined to employees.

The model evaluates the impact of the labour market policy changes on the labour market, including the changes of immigration policy, the number of study places, etc.

In the paper there are shown only significantly limited results of simulations: only common unemployed level and its changes after education and migration policy implementation, see Fig. 22.

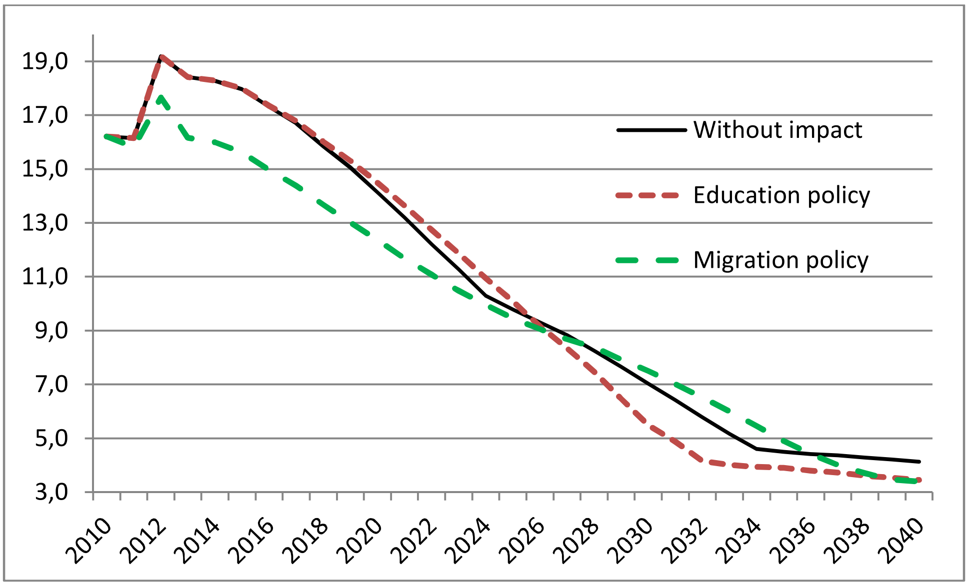

Fig. 22. **Unemployed level**

The simulations results show that the number of jobseekers and the unemployment rate are decreasing, taking into account the decline in the number of population and increase of the number of employed (due to the growth of GDP and increase of labour demand).

The results demonstrate that the education system optimization is acting over the medium term. This is related to the objective reasons: in order to prepare specialists with higher education, at least 4 years are necessary, additionally, the time is required from the formation of the shortage of occupations to the problem identification and opening of new study places, etc. Education policy allows reducing the number of employed and the unemployment rate prior to other affecting elements. However, the effectiveness of the state police also reduces, when the unemployment rate reaches 2-3%.

In a sort run the migration policy forces a decline in the number of jobseekers. It shows that in the situation with high unemployment, labour force leaves a state, as a result unemployment decreases. The migration policy reduces the speed of decline in the number of jobseekers in a long-time run. This is related to the fact that migration increases the population. The migration policy options are also limited, when the unemployment rate is on 2-3% level.

The section conclusion. Taking into account the model forecasting parameters, as well as possibilities to evaluate the impact of the labour market policy, it could be concluded that the developed model is one of the most powerful models in the World.

Conclusions

The analysis of the system dynamics method use for the labour market forecasting demonstrates that the selected method corresponds to the object. There exist many models developed, that could forecast labour market. It is possible to the use previous system dynamics practise for the new model development, by combining the best solutions from the existing models.

It is evident, that the system dynamics method, models are not used for labour market forecasting at the state level. Why? The analysis shows that there are a lot of system dynamics models for labour market forecasting. It is a big challenge for the system dynamics community. On a one hand, the method has changed the global development of the World; it has been used for business and enterprises problems solution; but, on the other hand, it has not been used for the annual planning at the state level. To the author's opinion, it is not a problem of the method, but the problem of community and researchers – the task of community members is to promote a method and to convince state officials to use the method for the state's needs. Latvia isn't a big state, the Latvian scientists are not very well known in the World, but the method is used for the state's needs in Latvia. This case can be as an example for all the community researchers, that with no dependence on a scientific rank, each scientist should successfully promote the method in his own area and country.

The model development experience shows that with the help of the method it is possible to develop the labour market forecasting and policy analysis model meeting the highest requirements.

Taking into account the model forecasting parameters, as well as possibilities to evaluate the impact of the labour market policy, the developed model is a one of the most powerful models in the World.

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