results and reproduction of the enterprise as a whole. Company needs to establish a system of depreciation, which will allow for depreciation in strict relation to the degree of IRE wear facility.

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5.5. Simulation model of labor supply and demand in Ukraine

At the present stage of economic development, the labor market and its processes play a significant role in regulating macroeconomic stability. According to this fact, the deeper research of Employment in Ukraine becomes more topical to prevent mass unemployment and job creation, which is vital in crisis period of not only economic but also political instability. It should be marked that labor market is influenced by many internal and external factors, and its research takes deep system analysis given complex nonlinear relationships between its main elements, which is impossible without adequate mathematical instruments, in particular, different labor market macro models of various levels of difficulty [2, 3].

Many Ukrainian and foreign scientists, such as G. Bardsen, G. Vdovina, O. Vorontsova, Ju. Virt, A. Glushach, E. Libanova, M. Oliskevitch, I. Petrova, M. Piters, E. Prushkivska and others research the theoretical and methodological basis of labor market formation, its significance in the economic system, specifics of state regulations of employment, estimation of its impact on economic sustainability and so on [1, 4-5, 7]. Highly appreciating

the achievements of scientists in this field, it should be mentioned that some problems need in-depth research. First of all, it concerns the formation of strategic vectors of labor market development regarding high risks and social-economic instability, use of modern mathematical instruments and system dynamics methods for research of complex nonlinear processes, which are typical for the labor market [4, 6].

Accordingly, the aim of the research is to build the general simulation model of Ukrainian labor market with system dynamics methods, which can help to analyze different scenarios of changes of main labor market indicators and their interactions for various development. The propose for this is to define adequate directions of strategic development of the labor market for the achievement of financial stability and social-economic development of the country.

For the last years should be noted that Ukrainian economy has suffered significant shocks, which reflected in low wages, the increase in the unemployment rate among the young population, decrease in vacancies and others. For example, the unemployment rate in Ukraine in period 2000-2008 was decreasing from 12% to 6,5%, but during crisis 2008-2009 it was increased to the level of 9%. In a period of 2010-2013 there was a tendency for improvement in the unemployment rate, it decreased to 7,5%, but in 2014, its level increased to 8,07% according to the data given by the statistics committee.

One of the problems in Ukraine is a high rate of Unemployment rate among the young population. The dynamics of this rate is seen in Figure 1.

The unemployment rate among young population is approximately 17%, which has the negative cause on labor productivity, and can cause the decline in working age population according to the fact that young people are more common to go abroad. The poor state of the labor market requires active government regulation by forming appropriate social-economic policy and determination of science-based directions of labor market strategic development with taking into account complex nonlinear dynamic relationships between main macroeconomic and labor market indicators.

The developed simulation model of Ukrainian labor market is based on system dynamics methods, which help quite easy to describe complex systems,

the behavior of which is studied over time depending on the structure elements and the interaction between them, including non-linear cause-effect relationships, delayed reactions, the influence of the environment.
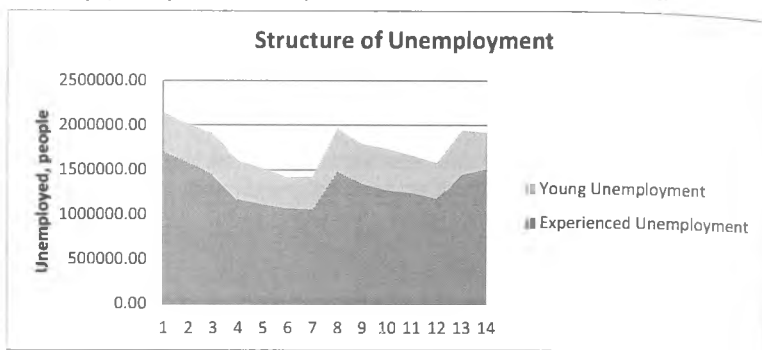

Fig. 1. Structure of Unemployment in Ukraine in 2001-2014
Source: built by authors on the basis of statistical data from State Statistics Committee of Ukraine.

The actual processes in system dynamics models are shown as stocks (rates of the indicators), flows (which influence stocks at the time) and convectors (parameters). The general scheme of the elaborated Ukrainian Labor Market Model is shown in Figure 2.
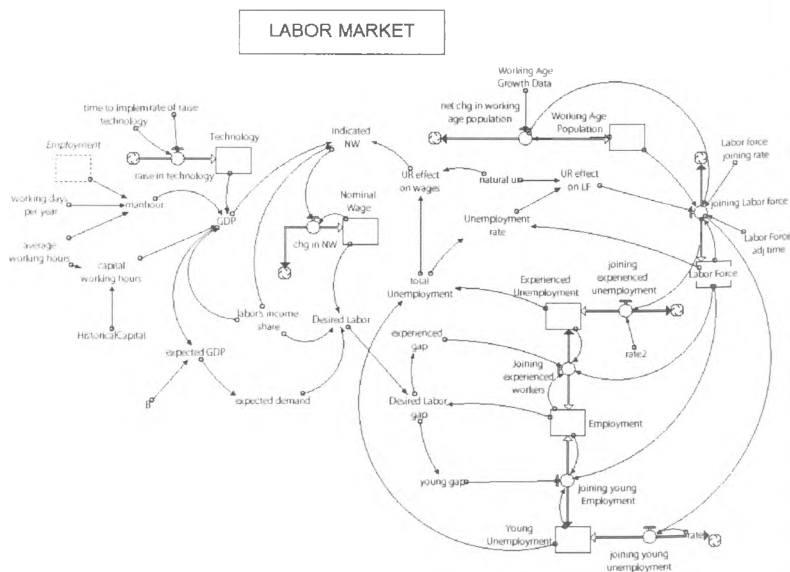

Fig. 2. General scheme of Ukrainian Labor Market Model

The built General Ukrainian Labor Market Model is conceptually related to the classic Keynesian models, has a block structure, and consists of 2 parts: the submodel of labor supply and the submodel of labor demand. These two interconnected submodels describe the formation of demand and supply in the labor market. Key indicators in the General Ukrainian Labor Market Model are the number of employed people (*Employment*), the number of unemployed people (*Total Unemployment*), *Nominal Wages*. These values are presented as stocks, changing by flows, which are influenced by dependent variables and constants. Equations define flows and variables, and constants based on statistical data. The interconnection between submodels is carried out by related parameters such as *Employment*, formed in the labor supply submodel and directly influences the GDP according to the production function, Nominal wage, which is formed as a part of GDP and influence the desired labor, Unemployment rate, which is formed in labor supply submodel as a part of labor force and has influence on the formation of nominal wages. The general scheme of the labor supply submodel is shown in Figure 3.
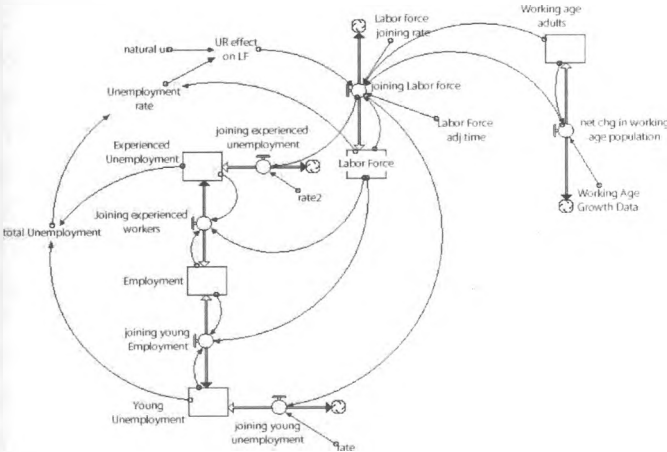

Fig. 3. The general scheme of labor supply submodel

The labor supply is determined by the number of economically active population and is represented as a stock of *Labor Force*. There is an assumption that there is a reinforcing loop between *Labor Force* and *Working Age Population*. The amount of Labor Force directly depends on the number of

Working Age Population, and according to statistics data, the amount of Labor Force is about 65% of Working Age Population. That means that with the growing of Working Age Population, the number of Labor Force will also grow. From the other side, the amount of Labor Force, or rather its structure, also has an influence on the forming of Working Age Population. With the high level of the unemployment rate, Working Age Population does not want to join the labor force, and very often they go abroad and stay there, which cause the decrease in fertility rate. By previous statistical analysis, it was determined that only 70% of people who reach the Working Age join the labor force. The equation of Labor force formation is:

$$Labor\_Force_t = Labor\_Force_{t-1} + \int_{t-1}^{t} (joining\_labor\_force)dt$$

where t – term of indicator's changing; *joining labor force* – is a flow that cause the changing of *Labor Force* stock and is set by the formula:

$$joining\_labor\_force = net\_change\_in\_working\_age\_population *$$
$$labor\_force\_joining\_rate + if (working\_age\_population > Labor\_Force)$$
$$then(UR\_effect\_on\_labor\_force * Labor\_Force - Labor\_Force)/$$
$$/ Labor\_Force\_adj\_time \ else \ 0$$

where *net change in working age population* is a flow, which influence the stock of *Working Age Population*; *labor force joining rate* – is a coefficient of *joining working age population* to labor force that is equal to 0,7 (or 70% according to the statistical data); *UR effect on Labor Force* is the impact of the unemployment rate influence on the amount of Labor Force: the higher unemployment rate, the less part of Working Age Population will join the Labor Force; *Labor Force adj time* – the time that is needed to evaluate the amount of Labor Force.

The number of employed people in economics is dependent from number vacancies (*Desired labor*). If the economic need for workers reduces, some vacancies become less. That means that employers fire their employees, or shut the vacancies, and visa verse with the rise of demand for employees, a number of jobs become higher. Equation sets the formation of employed in economics:

$$Employment_t = Employment_{t-1} +$$
$$+ \int_{t-1}^{t} (joining\_young\_employment + joining\_experienced\_workers)dt$$

where *Employment* is a stock of all the employed people; *joining young employment* is a flow of new employees of age 15-24 years; *joining experienced workers* is a flow of new employees with working experience.

The number of vacancies has the impact on the number of unemployed people, which is determined as the difference between Labor Force and employed people. The unemployed people in the model are divided into two categories: unemployed with work experience (*Experienced Unemployment*) and unemployed without working experience (*Young Unemployment*). The equation sets the number of young unemployment:

$$Young \_Unemployment_t = Young \_Unemployment_{t-1} +$$

$$+ \int_{t-1}^{t} joining \_ young \_unemployment - joining \_ young \_employment)dt$$

where *joining young unemployment* is a flow of unemployed without working experience.

During the research, it was determined that the number of youth unemployment is about 20% of total unemployment. The problem is that young specialists due to the complexity of getting the job quit the labor force and are more frequent for moving abroad.

The two submodels of the General model are connected according to the formation of Nominal Wage. According to the labor demand submodel, which general scheme is shown in figure 4, the stock of Nominal Wage is determined as the part of labor's income share in GDP, and is dependent on the amount of GDP, price index, unemployment rate effect on wages. The unemployment rate effect on wages consists in the fact that employers will not spend money on hiring new workers if the level of salaries is very high. The equation sets this dependence:

$$No\min al \_Wage = GDP \cdot labor's \_income \_share \cdot price \_index \cdot UR \_effect \_on \_wages$$

where *Nominal Wage* is the amount of nominal wage in GDP; *labor's income share* is the amount of the expenses on wages in GDP; *UR_effect_on_wages* is the parameter that shows the dependency between Unemployment Rate and GDP.

Expected GDP is determined according to the Okun's law and is dependent on the Unemployment rate and GDP in the previous period. The equation for Expected GDP is:

$$Expected\_GDP = \frac{GDP}{1 - \beta \cdot Unemployment\_rate_t - Unemployment\_rate_{t-1}}$$

where β is a parameter in Okun's formula, which is equal to 2.5; the *Unemployment rate* is a part of Unemployment in Labor Force.
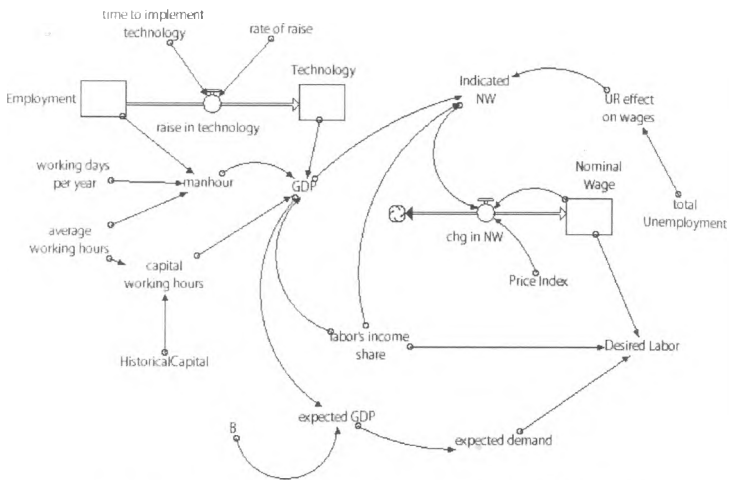

Fig. 4. The general scheme of labor demand submodel

Since the demand for labor (*Desired labor*) is dependent on demand for the production, there is an assumption in the model that expected demand is equal to expected GDP. According to this, the desired labor will be equal to the amount of nominal wage, which should be paid in the next period adjusting by price index and with taking into consideration expected demand for production:

$$Desired\ Labor = \frac{Expected\ demand \cdot labor's\ income\ share}{Nominal\ Wages/Emp\ loyment}$$

For simulation of designed model, which logically brings together labor supply and demand submodels, were used annual data for the period of 2002-2015 years. In the model, such data as *GDP*, *Working age adults*, *Employment*, *Unemployment*, *Nominal Wage*, *Average working hours* and *labor's income share* were taken from State Statistics Service of Ukraine. The primary criterion for adequacy of system dynamics model is the compliance of behavior between simulated and actual data for the main endogenous indicators in the retrospective period, which in our case has been found sufficient good.

From the model the scenario analysis of changes in GDP and wages depending on changes in the labor's income share and productivity (increased spending on new technologies) was conducted. The changes in GDP depending on scenarios are shown in the Figure 5.
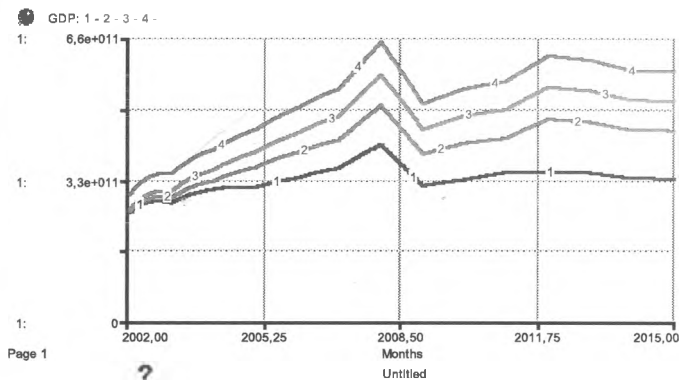

Fig. 5. Scenarios of GDP changes according to the change
in labor's income share and productivity level
Source: built by authors in iThink software.

In the Figure 5, the first scenario is the GDP in the current share of wages; second scenario is GDP with the proportion of wages on the level of 0.6 and third scenario is GDP with the share of wages on the level of 0.65. The fourth scenario shows the formation of GDP with labor's income share at level 0.65 and implemented new technologies, which would improve the labor productivity. For constant labor's income share of 0.65, the Nominal wage will increase from 838 bln UAH to 948 bln UAH. The comparison of the scenarios is shown in Figure 6.

In the Figure 6, the Scenario 1 describes the wages at level of actual labor's income share, scenario 2 – wages at labor's income share equal to 0.6, scenario 3 – wages at labor's income share equal to 0.65. Fourth scenario describes the change of wages accompanied by the introduction of new technologies and labor's income share equal to 0.65. According to the results of scenario analysis, it is better to change both productivity levels by buying new technologies and raise the labor's income share by producing added value. Under these conditions, the raising in GDP and as a result in nominal wages will be the best from these scenarios.
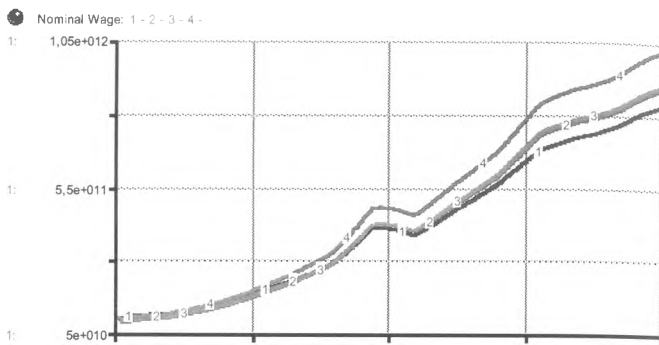
*Fig. 6. Scenarios of Nominal wages formation due to changes
in labor's income share and productivity*

Source: built by authors in iThink software.

Conclusions. Regarding significant social, economic and political challenges facing today before the Ukrainian state, the effective functioning of the labor market is crucial for the stabilization of the macroeconomic situation and for reducing social tension in society.

The productive employment is precisely one of the primary conditions for the solution of problems of the human labor potential, creativity, and talent implementation, and growth of the economy as the basis for social development. For most European countries, productive employment is the top priority of social and economic policy and fundamental basis of European integration.

The study showed that the main negative issues for Ukrainian labor market are reduce the number of economically active population, a high proportion of youth unemployment in total unemployment, low wages caused by the low share of wages in production, which could cause unemployment or outflow of labor abroad, as well as low labor productivity in Ukraine, which is caused by the use of old technologies in production.

On the basis of the Ukrainian market simulation model was performed the scenario analysis, which revealed the basic tools for labor market development, and allowed to quantify the impact of major labor market indicators on macroeconomic stabilization of the Ukrainian economy.

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5.6. The modeling of the dynamic relationships and shocks impact for socio-economic sphere in Ukraine

During the transformation period a socio-economic systems and labor market in Ukraine are in a difficult situation, when a considerable part of working population is in search of jobs, which is more often a condition for survival and provision the basis of human existence. In the present conditions of macroeconomic instability of the economy and strengthening of social tension various forms of unemployment exist as well as its overall level increases. Support for employment is an important condition for the functioning and development of society, the preservation and enhancement of its human capital. Overcoming the crisis on the labor market will contribute to social security of an individual and society from various dangers and will have an influence on social security of the state. Elaboration of strategy of socio-economic development in Ukraine and creation of effective system of its regulation that are designed for the long term, require investigation of an internal contradictions in the labor sphere, determination of basic quantitative and qualitative parameters of the future labor force.