Investments model development with the system dynamic method

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INVESTMENTS MODEL DEVELOPMENT WITH THE SYSTEM DYNAMIC METHOD

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Abstract
In the paper model of macroeconomic turnover and its possibilities for investments modelling are shown.
The model consists from four blocks: in the first the theoretical model is described. In the second the model is reflected in accordance with the requirements of system dynamics method, there are shown included influences intercommunications and equalizations. The third block examines demand and supply model for capital and investments. Fourth part complements previous parts, describes additional indexes.
The method is offered for using both in forecasting and in teaching.

Key words: investment, aggregated demand, macroeconomics, simulation model, system dynamics

Introduction

Research problem, novelty and relevance
Research problem. Development of economy of any country depends not only on GDP, consumption, export, but also from investments. In Latvia, in 2009, investment decrease was near 40%. One of possible decrease reason may be related with investment boom in Latvia in 2007-2008. In stabile development situation for investment forecast it is possible use statistical based forecasting methods, but in changes condition this methods do not work. In changeable condition for forecasting is necessary to use more powerful forecasting methods.
Research novelty. Really macroeconomic forecasting models in system dynamics created by economists are very rare. Mostly this type of papers is written by mathematics specialists; therefore they are not very popular among economists. First global model was developed by J.Forrester, but it was not economic model, but World dynamic model. Now better macroeconomic models are developed by Kaoru Yamaguchi (Japan), David Wheat (Norway). Yamaguchi model general part is related with financial markets and its place in macroeconomic turnover. Wheat model is developed in theoretical form, for teaching. Each model is related with its author and is unique. Each author develop model for specific condition or proceeding from personal understanding of a problem. Novelty of this paper is consisting with special role of investment in macroeconomic turnover. Investments determine development of economy not only for current moment but also for futures years.
Research relevance. Effective forecasting methods include the creating of macroeconomic environment model, and its uses for different indexes simulation, including investments. Traditional approach of macroeconomic model development is based on econometric method. But in very changeable condition this method does not work too. It takes place because method use statistical defined relation between indexes, but in boom or crisis time, it changes too. System dynamics method is rarely used, new method for investments forecasting and modelling. Its advantage is in possibility to use in non-stability, quick changes economic conditions, when forecasting with traditional quantitative methods is problematic. System dynamics method do not use statistical relation, but use analytical or logical relations system, which show excellent forecasting results in any condition.

Research object
Research object is macroeconomic and investment modelling system dynamics model.

Research aim
Research aim is to show macroeconomic and investment modelling system dynamics model.

Research tasks
Research tasks are to explain system dynamics method and it terminology, show income and goods circulation flow theoretical model, extend it in system dynamics model, specify investments role in macroeconomic system dynamics model, show additional parameters needed for model operating, analyze model and method possibilities in economic theory teaching.

Research methods

The paper shows system dynamics method use for macroeconomic and investment forecasting. This method is chosen for problem decision because it has advantages in comparison with traditional methods. In changes condition, boom and crisis time traditional methods do not execute the role. But system dynamics method is intended for long time forecasting in changes, indefinite condition.

Theoretical basis of system dynamics method and it use for macro process forecasting

System dynamics (systems approach, systems thinking) is an approach to understanding the behaviour of complex systems over time. It deals with internal feedback loops and time delays that affect the behaviour of the entire system. In economics system dynamics has researched the economic impact on the set of economical relationship among objects of study. Predicting economic behaviour of the object, the main task in the model is to reflect the real world analytically as correctly as possible; it is a challenge to any economist. Commonly used econometric methods are based on a statistically determined relationship/correlation, but system dynamics reflects analytically defined correlation results, and ultimately it could act in circumstances with changing statistical value of indicators. In other words, system dynamics answer the question should be the development, taking into account relations in the model.

System dynamics approach was created in the last century (in the end of 70s – beginning 80s) and developed by J.Forrester. Economic forecasting models in system dynamics created by economists are very rare, mostly this type of books is written by mathematics specialists, therefore they are not very popular among economists (Turnovsky, 2000; Sargent, 1987). Development of each method is depend from strong personalities, which use this method. For traditional sciences it development can depend from amount of it users (adopters). But in system dynamic we cannot tell that have much adopters, now in the Wold, in system dynamic society are less then thousand members, and near ¾ from them are economists (others use method in physics, engineering and so on). In small countries, as the Baltic States, this method is not known very much, for example, in Latvia there are only two scientists, which use this method, one physicist and one economist. In Germany there are near 60 specialist in system dynamic (including students), that is very small for developed, knowledge based country. According with scientist small amount, system dynamic researches, publications amount are limited, but each from them has good response. In Fig. 1 is shown scientist response (cities) on basic system dynamic publications.

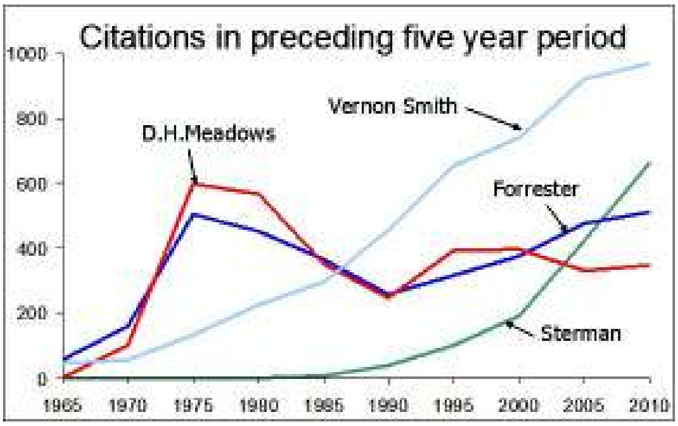

Fig.1 Citations in system dynamics in preceding five years periods (Moxnes, 2009)

Jay W. Forrester and Donella H. Meadows (first author of *Limits to Growth, 1972*) citations peak was after the publications of *World Dynamics, 1971* and *Limits to Growth, 1972*. John D. Sterman's career starts later and citations to his works show stronger growth than for Forrester and Meadows. It is three better authors in system dynamic. It is interesting to compare Sterman's citations to citations of 2002 Nobel laureate in economics Vernon L. Smith. Sterman's citations in 2009 are very close to Smith's citations in 2000. This mean, that for specialists they works may be equal. Currently the best book on system dynamics is J.Sterman's (Sterman, 2000). Unfortunately this book describes system dynamics approach in the business level or at micro level. At macro level we have not a lot of publications, but in different countries (Japan, Norway and Latvia) prepare to publication some macroeconomic model in system dynamic. Now better macroeconomic models are developed by Kaoru Yamaguchi (Japan), David Wheat (Norway). Yamaguchi model general part is related with financial markets and its place in macroeconomic turnover. Wheat model is developed in theoretical form, for teaching. The deficit of research in economic with system dynamic method gives unlimited possibilities for theory development.

In Latvia, system dynamic method has showed the best results in the construction sector, which had stated that the construction boom has no economic basis, but there are speculating reasons (Skribans, 2002). This method has also been used to estimate the credit burden potential of Latvian population (Skribans, 2008a), studied the labour and wage market in relation to migration from Latvia (Skribans, 2009a), modelled the mobile phone market development in Latvia (Skribans, 2008b), etc. The method has big potential in economic forecasting, however in Latvia its development hinder, firstly, high start-up costs of adoption (system dynamics software is rather expensive, 10 thousand. USD per license is not the upper limit). And, secondly, there are almost no lecturers in Latvia, who are willing to teach system dynamics courses. Positive side of method's development is that Latvian firms already see its advantages, and order researches with this approach in Riga Technical University. Therefore, with the aim of reflecting the opportunities and advantages of the method in investment modelling, the paper sets the task to explain the nature of method, what is done in this section.

This section describes basic elements of system dynamics mentioned in J. Sterman's book and further, a investment forecasting model is created on the base of these elements. It is important to note that the elements described below are widely used, but they could be somewhat different in other authors' or other recently published books. This is related with changes over time, technology development or alternative computer platform applications.

System dynamics graphical objects consist of the following elements: stocks, physical (material) flows, nonmaterial and information flows, flow regulators and converters. They are reflected in Fig.2.

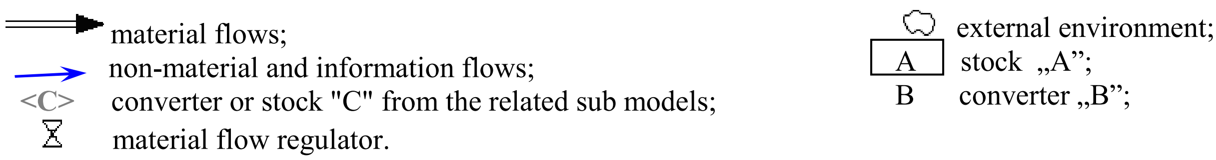

Fig.2 System dynamics elements

Elements consist of the following: stocks collect materials, money, people, reflect the stock of material, stock raising and using opportunities. Stock can be enter and exited from by material flows (cash, buildings, people, etc.). Physical inflows and/or outflows determine the stock increase and/or decrease. Stock is characterized by initial level and a maximum capacity; all other stages of stock are forecasting objects. Material flows can enter/exit in stocks and/or external environment. Amount of physical flow can be constant or variable over time, it is set regulators. Information and transmission of regularities is done by converters and information flows. Information flows transfer the information and/or operation from stocks, material flows, regulators and converters to the material flows, regulators and converters. In this case, converters process the action or information. Converters can not only process information, transmit it, but also store it. The external environment is an artificial object, which can both supply and consume everything. Fig.3 reflects an example of dynamics model which combines all the above-mentioned elements.

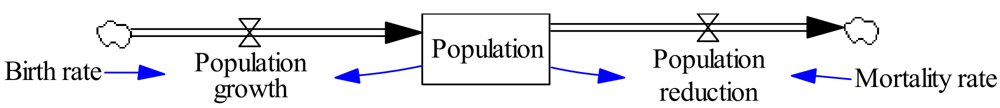

Fig.3 System dynamics model example for Latvian population grows

Graphic images in dynamic modelling are usually duplicated by mathematical formulas.

Population = INTEGRAL (Population growth - Population reduction, 2261294)
*Population growth = Population * Birth rates* (1)
*Population reduction = Population * Mortality rate*
Birth rate = 1.4 / 1000
Mortality rate = 13.7 / 1000

Formula (1) reflects the data from model Fig. 3. This is a simple model and it serves as an example of system dynamics model. In the model one stock shows population. Two material flows with their regulators - grow and reduction. Population growth and reduction depends from the population and corresponding coefficients,

as shown by the information flows in Fig.3. Image only reflects that one element is connected with other, but the formulas specifies relationship among elements. The model also has two converters: the birth and mortality rates. Simple formulas are enclosed in these ratios, but they could also include variables complex.
Using the dynamic modelling techniques presented in this section can create any degree of complexity of forecasting models, testing with it various economic theories and assumptions. The offered investments forecasting model is shown below.

Macroeconomic system dynamics model general scheme

The development of macro economical or sector model is an ongoing scientific work, which could not be done instantaneously, without careful preparation. Also, this paper presents a model which is produced in different years. The first preparatory phase of the model was completed in 2008. This paper author, together with Dr.habil.oec. R. Počs, conducted research project on Latvian business competitiveness. Research analyzed Latvian economy in subsectors, and, combining them and adding some sub-blocks, was designed system dynamics model for business competitiveness (Skribans, 2010). At the beginning of 2009, considering the rapid change in the national economy, as well as tax policy changes, the model was adapted for the tax revenue and state budget forecasting. Model has good forecasting quality, but take into account that the model brings together all sectors of the economy, further use of the model requires significant work, updating and maintaining databases. Also the model of mutual correlations is so diverse and wide, that the model adoption also takes some time. Therefore the model is used by narrow circle of specialists. At the beginning of 2009 the author of this paper made first attempt to develop a model, which would be easy and comprehensive for all economists (Skribans, 2009b). Unfortunately, this model was not published, but this paper slightly talks about its performance. Since that time model is significantly revised, it contains more correlations, and it is more detailed. But compared to the model of 2008, it is no longer possible to estimate the individual economic sectors development. A general scheme of model is shown in Figure 4.

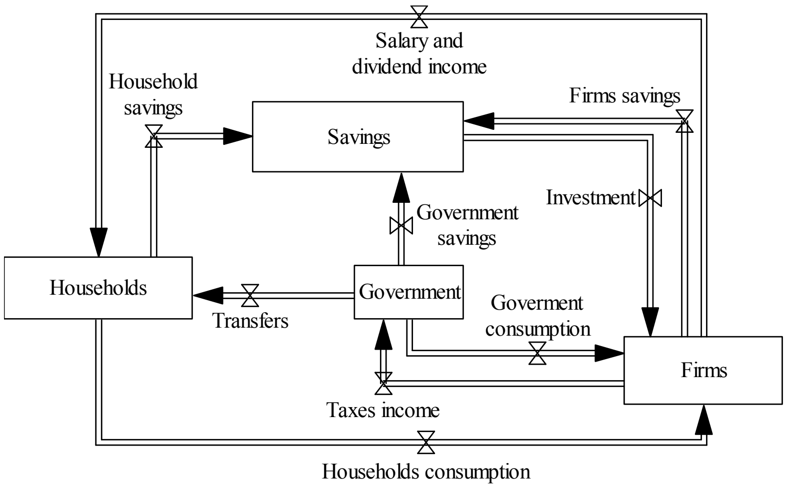

Fig.4 Macroeconomic system dynamics model general scheme

Fig.4 shows, that the system dynamics model is based on the model of macroeconomic flows.
Model base consists from households and firms. Households own all the resources. They supply labour force, material and other resources. Households create demand and consumption of consumer goods and services. In the model household demand is described as *Households consumption*, i.e., the sum that firms receive from households in exchange for manufactured products. Households pay for the goods at the expense of income received from firms for use of labour, land and other production factors. One of the specific types of income is dividends that households receive from firms for the use of the business factors. All households revenues obtained from firms are summed up into one flow, which is marked as *Salary and dividend income*, there is underlined the importance of wage income to households, and importance of dividends - to the firms.
Not only households and firms, but also the savings are reflected in the common framework. Households could spend part of their income for consumption, and other - save. Also they could spend more than it is received from firms, paying the difference with credit assistance. It is a negative form of savings. In the general model both household savings and household loans are reflected in a one flow, which is designated as the *Households savings*. Household savings together with firms' and government savings form total

savings, in the model denoted as *Savings*. Unlike households, firms' savings and savings use is reflected in two flows, i.e., *Firms savings* and *Investment*. According with economic theory, the amount of total investment should comply with amount of total savings. The proposed model allows realizing this principle. It is also possible to add external environment block, through which it is possible to increase both the amount of investment in economy, and household consumption. This paragraph also refers to the government savings. In the model it is the total balance of government savings and loans. Government savings, the same as household and business savings, impact total savings. Considering government's special role if the macroeconomic turnover model, government's action is discussed separately.
The government is another one subject in the macroeconomic turnover model. Its role is to stabilise the economical situation and fulfilling overall social interests. The government carries out its tasks, collecting taxes, paying transfers to citizens and commissioning various products and services to firms. In the best case, the amount of collected taxes should match the amount of transfers and public procurement, in that case, the government has no loans and no savings. If spending exceeds the income, government has to borrow money, or otherwise make savings. Government related flows in model are referred to as *Transfers* – net transfers paid to households, Government savings, Government consumption and Taxes income.
From economist's point of view, this description is not novelty; it can be visible in different economic books (Долан and Лидсей, 1994). The element of novelty is related to the creation of mathematical formulas in the system dynamics model. Analyzed correlations are very complicated for traditional economic forecasting. There are many reflective connections, which are not possible to describe using linear or similar equations. The described turnover in the system dynamics model from theoretical becomes to the real economic forecasting circles. A more detailed description of these equations is made in the following section.

Advanced macroeconomic system dynamics model

The model discussed in the previous chapters is supplemented with influencing parameters and equations, and it is reflected in Fig. 5.

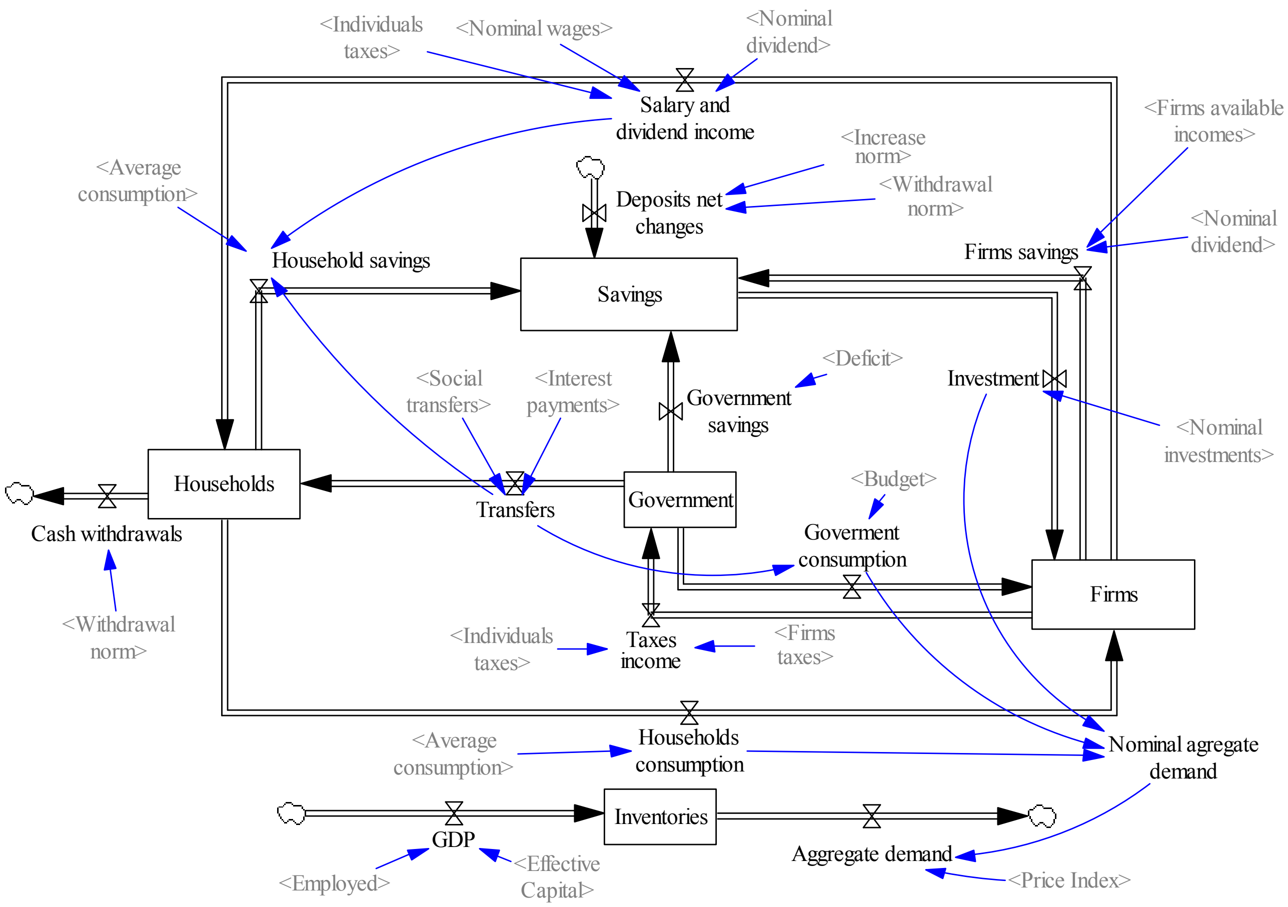

Fig.5 Practical realization of the system dynamics model

According with Fig. 5 are formed system dynamic formulas.

Households = INTEG (Salary and dividend income + Transfers - Households consumption - Household savings - Cash withdrawals, initial level) (2)
Firms = INTEG (Investment + Households consumption + Government consumption - Salary and dividend income – Taxes income – Firms savings, initial level)
Savings = INTEG (Firms savings + Households savings + Deposits net changes + Government savings – Investments, initial level)
Government = INTEG (Taxes income - Transfers - Government savings - Government consumption, initial level)
Inventories = INTEG (GDP - Aggregate demand, initial level)
*GDP = (Employed ^ Production function coefficient) * (Effective Capital ^ (1 - Production function coefficient))*
Aggregate demand = Nominal aggregate demand / (Price Index / 100)
Nominal aggregate demand = Households consumption + Government consumption + Investment
Salary and dividend income = Nominal wages + Nominal dividend - Individuals taxes
Taxes income = Individuals taxes + Firms taxes
Firms savings = Firms available incomes - Nominal dividend
Households savings = Transfers + Salary and dividend income - Average consumption
Deposits net changes = Increase norm - Withdrawal norm
Transfers = Social transfers + Interest payments
Government consumption = Budget - Transfers
Households consumption = Average consumption
Cash withdrawals = Withdrawal norm
Investments = Nominal investments
Government savings = - Deficit

Where: INTEG (**a**, **b**) - the integral from **a**; in starting point, where it is impossible to calculate the integral, the function adopted **b** value.

Fig.5 shows that the practical realization of the system dynamic model is repeat Fig.4 stock and flows. The aim of this section is to describe and explain the model forming relationships. It is important to note that the Fig.5 is supplemented with stock - *Inventories*, its forming flows, *GDP*, *Aggregate demand*; and households stock is supplemented with flow - *Cash withdrawals*. This will be discussed below.

The first stage to explain Fig.5 and its forming equations is a description of stocks. The equations show that volume of stocks is calculated from the initial volume, integral from incoming and outgoing flow difference. Actions of stocks and flows were generally described in the previous section; thereof here are only reflected previously not described stocks and flows. First of all, the flow - cash withdrawals from households - has been established to display the amount of money what households withdraw from economical flow. It complements the household savings flow. The household savings flow is made savings, which later could be used for investment or other purposes, but the cash withdrawals create household savings, which does not participate in the turnover, but this money could be used if households would be in financial difficulties.

Substantial improvement is associated with the stock - *Inventories*. Firstly, it reflects inventories in system and, secondly, it reflects gross domestic product (*GDP*) from production and expenditure side. In short-term production of goods may be do not match the consumption, in the given circumstances material stocks are growing or decreasing. Modifications of inventories could cover with the external environment (international trade). Thus, in model inventories complement GDP, which is the total value of all in state produced goods and services. GDP model is calculated using Kobb-Douglas production function (see Equations 2). GDP depends on the labour and capital using intensity. In the model, they are shown as *Employed* and *Effective capital*. Variables - employees and effective capital - do not included in the classical macro economical flow, they are not reflected in the basic section of the model, but it is indicated that they are from the related sub-model. Unfortunately, due to the limited pages of the paper, it is not possible to show all sub-models and their variables, so the variables of the related subsections will not be discussed in the paper. Next inventories related flow is aggregated demand; usually it is estimate GDP from expenditure side. In the model the aggregate demand is analyzed considering price changes. The *Price index* from sub-model and *Nominal aggregate demand* form calculation of aggregate demand. Aggregate demand is calculated as nominal aggregate demand divided by the price index (see Equations 2). Nominal aggregate demand, according to the economical theory consists of household consumption, government consumption and investment; the same way it is calculated in the model. Model show closed economic system, and the external environment (or international trade) are not show in the paper.

Further we will discuss the model forming flows. From the author's point of view, all other equations reflected in the model are simple; it is no longer necessary to explain them. For example, salary and dividend income flow is equal to the sum of nominal wages and nominal dividends minus personal taxes, what are

shown in Fig.5 and its equations. Problems could arise if the model equations show that some indicator is influenced only by one parameter. For example, households consumption is equal to the average consumption or government savings are equal to the minus government deficit. That is due to the fact that in the present basic model these values are not defined. They are defined in another sub-model; and according to the above mentioned limitation will not be reviewed in the paper.
Take to account that paper theme is constrained with investments, farther in work examined investments sub-model.

Investment model

In sub-model creation one important role is to understand concept of investments. In a theoretical macroeconomics with it understand the production of products, which not be spent, but will be used in the future, let product consumer products. Ordinary it extends in money expression. This definition is clear and don't need explanations, but further offered to look over it from anther point of view, not from the investment definition point of view, but from consumer products. Or answer a questions, why are investments necessary for production of consumer goods.
So, in order to produce goods there are necessary resources. It is possible to acquire by using a capital. In the production process also is necessary capital. Accordingly one from alternative definitions of investments can be following: investment is production capital increase in the economic system. Accordingly, for estimating of productions capital increase there is necessary comprehensive analyse on capital actions (increase and diminish) influential factors.
First of all, will accept, that the long run expected demand is known. In each economic system it can be characterizes with the Leontief production function coefficients, which stipulate production resource and output correlations. If take capital and output correlations, together with the long run expected demand it is possible to estimate amount of capital witch allow produce according demand. Next, by knowing desired and actual capital it is possible to determine lack of capital. It is important to retreat from the above-mentioned idea by the author and it should be explained and reminded, that it is necessary to analyse not only needs and the actual capital, but also that capital, that leave the system, it can be called as capital diminish. Capital diminish is constrained with capital limited life time. Investing means each investor plans to return means back. Accordingly with it, in the state, it is possible to calculate the average investment time, or capital average life time. The invested capital leave system after it average life time. Accordingly on this sum are necessary to attract capital, let to provide output level. Together with required and actual capital, capital diminish stipulates lack of capital. Also, if we take into account capital diminishing, in future it will allow calculate net capital changes.
Knowing lack of capital, it is possible to attract capital. In reality, to attract capital it is not possible immediately, but after some time. Also capital attract is possible only in case if in the system are savings. Described relations in graphic form are represented in Fig. 6.

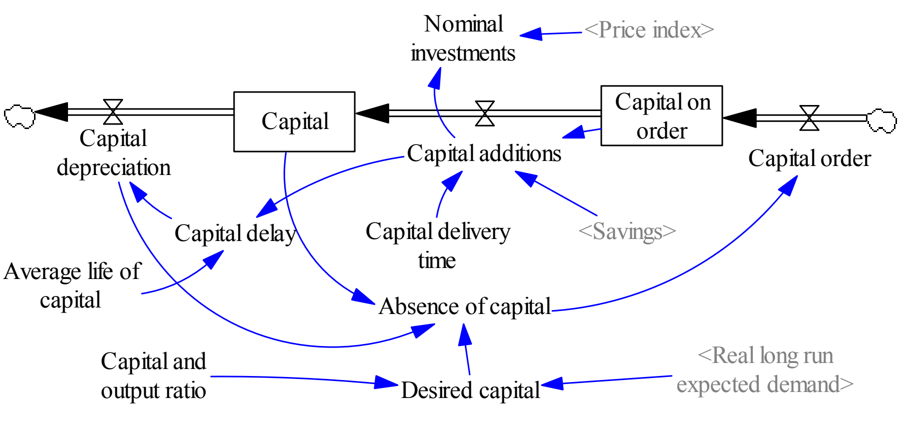

Fig.6 Investments model

According with Fig. 6 are formed system dynamic formulas.

Capital = INTEG (Capital additions - Capital depreciation, initial level) (3)
Capital depreciation = Capital delay
Capital additions = MAX (0, MIN (Savings, Capital on order / Capital delivery time))
Capital on order = INTEG (Capital order - Capital additions, initial level)
Capital order = Absence of capital
Capital delay = DELAY FIXED (Capital additions, Capital delivery time, Capital / Average life of capital)
Absence of capital = Desired capital + Capital depreciation - Capital
*Desired capital = Real long run expected demand * Capital and output ratio*
*Nominal investments = Capital additions * (Price index / 100)*

Where: MAX (**a**, **b**) - logical choice operator, return maximal value of **a** or **b**;
MIN (**a**, **b**) - logical choice operator, return minimal value of **a** or **b**;
DELAY FIXED (**a**, **t**, **b**) - time delay operator, delay **a** at **t** time, before it, it is used **b**.

In generally, relations represented in Fig. 6 were analysed beforehand. Separate indicators, such as *Average life of capital*, *Capital and output ratio*, *Capital delivery time* can be taken as fixed for different states. In a sort-run this is according with real life. These indicators theoretically can changes in a long-run, but in a sort-run their changes are not visible.
It is necessary to explain with Fig. 6 constrained equalizations. It is evidently, that for capital increase is applied expression Max (0, (Min (**a**, **b**)). It provide, first of all, let capital increase is positive (maximal with compared with a zero) and, secondly, let be select a capital increase less from savings (**a**) and from ordered capital (**b**). Theoretical, in populations diminishing case, demand can diminish. In such circumstances use of capital must diminish. But it diminishing will take place gradually, take into account *Average life of capital*. Next argument, why this limitation is necessary, is such, that investment can not be negative. The positive capital increase is provided by operator Max (0, **Y**). In demand diminish case this model can estimate *Effective capital*, i.e. such capital, which corresponds to a new, diminished demand taking into account Leontief production function. Operator Min (**a**, **b**) provide logical choice between an investment volume: it is no needed added capital more than is ordered and it is impossible to add anymore, than are in savings. All other equalizations it is simple and do not require additional explanations.
It is necessary to say about investments sub-block relation with basic model and other model indicators. From general scheme, analysing Fig.5, it can draw conclusion, that investments is possible only in case if there are savings in the system. Accordingly in Fig.6 there is visible a variable *Savings* from basic model. Also *Price index* already was mentioned in basic model. Variable *Real long run expected demand* is from expected demand sub-model and it will be examined later.

Expected demand

Determination of expected demand is based on estimation of aggregate demand, material inventories and on estimation time of their changes. This model is represented in Fig. 7.

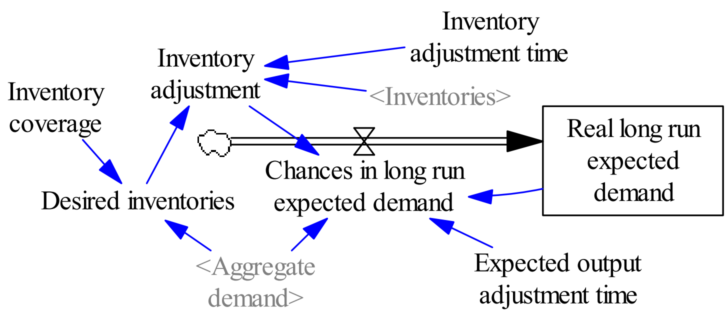

Fig.7 Expected demand model

According with Fig. 7 are formed system dynamic formulas.

Real long run expected demand = INTEG (Chances in long run expected demand, initial level) (4)
Chances in long run expected demand = (Aggregate demand + Inventory adjustment - Real long run expected demand) / Expected output adjustment time
Inventory adjustment = (Desired inventories - Inventories) / Inventory adjustment time
*Desired inventories = Aggregate demand * Inventory coverage*

The *aggregate demand* and *Inventories*, which beforehand are examined in general model, serves for expected demand model as the start point. Times of changes, that also *Material coverage* are fixed coefficients, which it is possible to calculate for each state separately. Coefficient *Material coverage* shows need correlation between material inventories and aggregate demand. This coefficient very slightly changes in time, therefore for short and middle term forecasting it is taken as fixed. In case if aggregate demand changes, then according to this coefficient it is possible to calculate desirable materials inventories. From required inventories, taking into account actual inventories and time of their changes, it can calculate the changes of the inventories. Inventories changes, aggregate demand and time of output change in aggregate forms changes in expected demand. Taking into account changes in expected demand, a previous period expected demand, it possible to calculate expected demand.

Alternative application of model

The model use in investment forecasting is not the one way of model application. System dynamics could be used not only in economic forecasting, but also in student teaching, lecturers' qualification raising etc. Unfortunately, this part of system dynamics is not developed in Latvia. Researches show (Wheat, 2007) that the students choose to acquire knowledge of macroeconomics using the system dynamics method rather than traditional methods. This is related to the transparency of the method, students do not study statistics, analytically theoretical methods, but on real data make sure that the change of one parameter could affect macroeconomic flows throughout system. Consequently, compared with traditional methods of training based on system dynamics approach give better results, students show better understanding of the macro economical processes (Wheat, 2007). Hopefully soon in Latvia the system dynamics model will be used for both forecasting macro economical processes and teaching at higher education institutions.

Conclusions

1. In the paper the macroeconomic and investment modelling system dynamics model is work out. The research aim is reached. There are completed all research tasks: system dynamics method and it terminology are explained; the circulation flow model is show both theoretical and in system dynamics form; separately investments role and additional parameters are shown; model and method possibilities in economic theory teaching are analyzed.
2. The represented model is produced only in a theoretical form, till with it to represent the results of model action it is not possible. To finish models are necessary to execute a national economy analysis (it is possible to do for any country), calculate separates fixed coefficients. The beforehand finished researches, development of models with a system dynamics method in Latvia in construction sector (Skribans, 2002), in population potential credit burden estimation (Skribans, 2008a), in mobile phone market analysis (Skribans, 2008b), in migration, labour and wage market research (Skribans, 2009a), and in national business competitiveness study (Skribans, 2010) confirms in the paper provided conclusion, that in the Baltic States, for forecasting economic processes, this method is befitted than other.
3. The model use in investment forecasting is not the one way of model application. System dynamics could be used not only in economic forecasting, but also in student teaching, lecturers' qualification raising.

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Investments model development with the system dynamic method

Summary

Развитие экономики Латвии, как и любой страны, зависит не только от ВВП, потребления, экспорта, но также и от инвестиций. Инвестиции определяют развитие экономики не только на текущий момент, но также и для последующих лет. В Латвии, после продолжительного, более десяти лет, прироста объемов инвестиций, в 2009 году объем инвестиций сократился почти наполовину. О возможности сокращения инвестиций предупреждал ряд экспертов, но, в тоже время, качественных прогнозов о времени изменения тенденций и грядущих объемах инвестиций предоставлено не было. Отсутствие действенных суждений о развитии ситуации наряду с важностью проблемы в народном хозяйстве в целом определяют практическую актуальность прогнозирования объемов инвестиций. Один из возможных методов прогнозирования состоит в создании макроэкономической модели окружающей экономической среды, и ее использования для моделирования различных показателей, включая инвестиции. В данной статье для моделирования макроэкономической среды предлагается использовать метод системной динамики. Метод системной динамики является новым методом для прогнозирования и моделирования инвестиций. Преимущества метода заключаются в его возможности применения в нестабильных, быстро меняющихся экономических условиях. В таких условиях прогнозирование традиционными количественными методами весьма проблематично. Традиционно используемые методы статистического прогнозирования не могут показать моменты изменения тенденций, а лишь находят и продолжают имеющиеся тренды. В условиях приближения кризиса результаты традиционных методов статистического прогнозирования идут в разрез с мнением экспертов, которые на основе опыта заявляют, что рост, как и падение, не могут продолжаться бесконечно. Но эксперты не указывают точного момента изменения тенденций. Метод системной динамики на основе имеющихся взаимосвязей и ограничений показывает пределы роста, и при приближении показателем пределов замедляет темпы основного тренда. В частных случаях метод системной динамики может указывать на изменение тенденций, а так же на цикличность развития экономики, инвестиций и т.д.

В статье показан метод системной динамики и его терминология. Коротко описано становление и развитие метода, указанны основные специалисты, признанные на международном уровне, упомянуты их труды. Метод системной динамики это подход к пониманию поведения сложных систем в течении времени. Он оперирует с системой показателей, их взаимосвязями, внутренними петлями обратных связей и временными задержками, которые затрагивают поведение всей системы. В экономике системная динамика изучает влияние совокупности экономических отношений и взаимосвязей среди объектов исследования. Прогнозируя экономическое поведение объекта, главная задача модели состоит в том, чтобы аналитически отразить реальный мир настолько корректно, насколько возможно; и это является вызовом и задачей любого экономиста. К сожалению, общностью экономистов метод системной динамики не воспринимается как экономический метод изучения экономических взаимосвязей, а воспринимается как математический метод. Поэтому в среде экономистов данный метод мало распространен. Применением метода в странах Балтии в большей степени занимаются математики, программисты. Как следствие - большинство разработанных моделей с использованием метода системной динамики не обладают должным уровнем экономического познания. Данная статья является одной из первых попыток построить модель макроэкономического равновесия, инвестиций с точки зрения экономиста.

В статье показана модель макроэкономического оборота ресурсов, товаров и доходов, представлены её возможности для моделирования инвестиций. Представленная модель состоит из четырех блоков: в первом блоке теоретически описана модель макроэкономического оборота ресурсов, товаров и доходов. Основу модели формируют домашние хозяйства и фирмы. Домашние хозяйства формируют внутреннее потребление, предоставляют предприятиям рабочую силу и, в соответствии с экономической теорией, другие ресурсы, имеющиеся в государстве. Фирмы, в свою очередь, производят продукцию, товары и услуги; оплачивают предоставленную рабочую силу и производственные ресурсы; выплачивают дивиденды домохозяйствам. В общую структуру модели, в модель макроэкономического оборота включены сбережения. Сбережения формируются как совокупный баланс сбережений домохозяйств, фирм, правительства и инвестиций. Согласно экономической теории, суммарный объем инвестиций должен совпадать с суммарным объемом сбережений.

Предложенная модель позволяет реализовать этот принцип. Следующий сегмент, включенный в модель макроэкономического оборота, - это правительство. Правительство влияет на макроэкономический оборот посредством налогов, потреблением товаров и услуг, производя выплату трансфертов, а так же участвуя на финансовых рынках, выступа в роли дебитора или кредитора. Важную роль в макроэкономическом обороте играет изменение материальных запасов, что отражает следующий сегмент, включенный в модель. В определенных условиях рыночная модель может терпеть фиаско: вследствие перепроизводства товаров, на некоторое время объем производства может упасть до нуля, но это не вызывает не стабильность или коллапс всей системы. Наличие материальных запасов может компенсировать кризис в производстве. Представленная модель отражает закрытую экономическую систему, внешняя среда (или международная торговля) в статье не показана, что является ограничением статьи. Во втором блоке упомянутая теоретическая модель отражена в соответствии с требованиями метода системной динамики, показаны включенные экономические взаимосвязи и их уравнивания. Рассмотрены потоки, формирующие модель.

Третья часть исследует формирование спроса и предложения на капитал и инвестиции. В данной части так же рассмотрены взаимосвязи подблока инвестиций с основной моделью и остальными показателями в модели. В основе определения объема инвестиций лежит сравнение фактически имеющегося и необходимого для производства капитала. Их разность, в случае превышения потребностей в капитале, показывает объем инвестиций. Необходимый для производства капитал определяется исходя из ожидаемого потребления (спроса). Привлечение необходимого капитала, или инвестиций, происходит с определенной временной задержкой, что вызывает циклические и затухающие колебания в экономике.

Четвертая часть дополняет предыдущие части, описывает для их функционирования необходимые показатели, такие как формирование ожидаемого потребления, наличие и изменение материальных запасов в системе. Ожидаемое потребление (спрос) определяется исходя из долгосрочного ожидаемого спроса, краткосрочных изменений в материальных запасах, временных задержек, связанных с необходимостью привести выпуск продукции в соответствии со спросом.

В конце статье метод системной динамики предлагается для использования не только в прогнозировании макроэкономических показателей, инвестиций, а также и для обучения экономической теории. Исследования показывают, что студенты заинтересованы в получении знаний по макроэкономике с использованием метода системной динамики более чем с применением традиционных методов. Так же использование метода системной динамики в процессе обучения повышает уровень освоения и восприятия экономических знаний.