

Model of the control system of national economic security

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Abstract. The article outlines a diagnostic model for controlling the national economic security. The diagnostic approach was characterized as the tool for assessing economic security and availability of means. The author described dynamic CLD (Casual Loop Diagram) models with respect to diagnostic testing of financial security and availability of strategic means, and then discussed critical elements that should be taken into consideration while calibrating both models.

1. Introduction

The security theory, including economic security, was relatively well recognized and described at the level of both description and definition. There is extensive and easily accessible literature on the subject. The issue of computation, which would allow intentional control of particular parameters of the national security, still remains open and not very advanced. It is due to the fact that experts have insufficient knowledge of the methodology, which would allow to currently track, dimension and draw conclusions from the analysis of quickly changing large sets of data concerning the national economic security. Therefore, at present, the main problem is not the inability to recognize the scope and type of risks, but insufficient availability of techniques allowing to control such risks in terms of computing and decision-making. The problem is by nature structurally complex. It is necessary to apply appropriate solutions both at the level of the whole economy and objects, which refer to a safe level of availability of particular means. Generally, the problem must be solved at the meeting of the following disciplines: economics, advanced information technology, defenses and law. The objective of the article is to formulate the model of the national economic security using systems dynamics methods described in [13, 14] and analyse possible casual loops and their mutual effect and then find critical elements that should be taken into consideration while calibrating the model.

2. Diagnostic approach to assessment of macroeconomic security

The national economic security is only one of the assessment attributes. Comprehensive assessment of the country's situation at a given moment is the result of many processes that have been undergoing for many

years, sometimes even centuries. What is more, these are multilevel and multicomponent processes implemented in specific environment of external factors. All of this contributes to the emergence of specific characteristics of a given country, which need to be included at every level in the temporary decision-making process. Therefore, the following rule may be put forward: "If the following characteristics may be simultaneously assigned to a given country: compliance with all qualitative norms in all (material and non-material) areas of activities, common rule of economical use of all available goods, stable and well-organized social relationships as well as trends of steady improvement of economic results, it is possible to assume a priori that the country is by nature safe, of course, provided that there are no military threats. However, first, it is important to know this and to know this, it is important to have an appropriate diagnostic system. However, such system does not have to be mathematically formalized in case of all of the aforesaid characteristics. However, when it comes to the economic situation, there are no other reliable methods. Until recently, a large number of data that need to be analyzed and with respect to which correlations need to be found constituted a serious obstacle. The application of approximate indicative methods used by the teams of analysts and experts (that had to be developed) does not efficiently and safely solve this problem due to a limited time and requirements of the reasonable level of employment. Nowadays, such problem is removed by the AI techniques. To use them, it is necessary to deliberately abandon expert knowledge to use the knowledge hidden in the data processed by the transactional systems. The amount of hidden knowledge which may be potentially used should be the main criterion for selection of an appropriate set of transactional information that constitutes direct subject of the diagnostic test. Therefore, there is a need to construct an intelligent system for testing economic situation -

both at the level of the country and larger strategic companies and corporations. The so described problem concerns the model for testing the national economic security, which falls within the scope of economic diagnostics. The theory of economic diagnostics is a part of the discipline which has been recently referred to as the "automatic management". Since the medical and technical diagnostics have been known for many years now, the economic diagnostic is a relatively new discipline, which emerged together with the integrated IT systems type ERP, MRP, HRMS or BI, supporting the management process in a company, and with development of methods of data exploration, i.e. the microeconomic issues. Cholewa and Kościelny [1] define the process of diagnosing the status of objects as the "sequence of tests, in particular for two-class spaces of statuses (fit/unfit) or requiring special procedure allowing to recognize the status, which happens especially when the number of classes of the status is large" - which is the case of the economic diagnosis. On the other hand, Gołuchowski points out that [2]: "The fundamental result of diagnostic testing (reasoning) is an explanation of the present, past or future state of affairs described by way of the collected symptoms. Therefore, it is not a goal in itself, but constitutes an element of a much broader procedure. When analyzing the considerations on solving the economic problems, it is apparent that the diagnostics are analyzed, among other things, in the context of:

- organized actions;
- decision-making process;
- early warning system;
- controlling.

Emory and Niland [3] distinguished three stages of the decision-making process (establishment of goals and potential partial tasks, task solution), assuming that the diagnostics are part of the process for determining tasks that need to be performed to achieve the goals set in the first phase of the process. While identifying the problem, which is one of the partial tasks, the data are analyzed to detect some deviations (differences, discrepancies) between the current situation and predefined goal or pattern. In case of any material deviations, they shall be recorded as symptoms subject to analysis (recognized and explained) during the diagnostics. The above-described process was shown in Fig. 1.

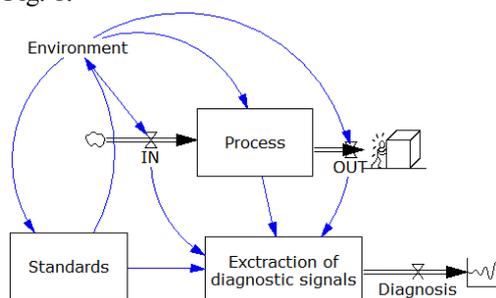


Fig. 1 Process of economic diagnostics

The economic diagnostics should be considered one of the stages of the decision-making process, based on the

symptoms signaled by the system, differences between the obtained results and previously set tasks. The risk symptoms may equally well result from wrong determination of the goals as well as incorrect execution of the tasks or both these factors which occurred simultaneously. Therefore, to properly diagnose the macroeconomic situation, the correctness of the method for setting the tasks should be also controlled and assessed. The method must guarantee a specific level of reliability subject to measurable assessment. What is more, if the method is to be assessed in a formalized manner, it has to be formalized as well (algorithmized). As a result, the point is to construct an intelligent system for diagnosing the economic situation. Such an approach seems to be especially promising in terms of solving the issue of the economic diagnostics in the national economic security diagnostics due to its complexity and versatility. Apart from other long used and hence well-developed methods of technical diagnostics, the introduction of economic diagnostics to the management process of the national economic security is surely aimed at improving reliability of the whole process. Diagnostics of all elements should soon lead to a situation when it is possible to talk about the reliability of economic functions performed in a country or a company as a whole, making them comparable in that respect. The need to search for such integrated technical and economic solutions has become more obvious in current circumstances. In the conditions of absolute competition on the market saturated or sometimes even oversaturated with supply, it is often the case that companies collapse despite modern and reliable technical base. They collapse because the economic situation was not assessed in a precise manner. Colloquially speaking, it does not really matter if a specific device was sent to the scrap heap, because it was unreliable or because it became a part of the estate bankruptcy due to the decision of an official receiver. Currently, the problem which needs to be addressed in the first place is the issue of economic diagnostics using methods of the highest degree of reliability. As a result, on the basis of the already known general definitions of diagnostic activities, and while considering the fact that what is needed are the solutions for assessment of the whole economic situation in a country or production company, the following definition was adopted: diagnostics of the economic situation of a company means identification of causes and consequences of its past or future changes. Such an approach seems to be especially promising in terms of solving the issue of the economic diagnostics in the national economic security diagnostics due to its complexity and versatility. Apart from other long used and hence well-developed methods of technical diagnostics, the introduction of economic diagnostics to the management process of the national economic security is aimed at improving reliability of the whole process.

3. Availability of means as the national economic security factor

For the purpose of the approach proposed in the title of this chapter, it is necessary to appropriately define the term "national economic security". Książopolski defines the economic security as [4] : "...uninterrupted functioning of economies, i.e. maintenance of basic development indicators and guarantee of comparative balance with economies of other countries". Raczkowski proposes another definition: [5] "... the national economic security is a relatively sustainable endogenous and exogenous state of the functioning of the national economy, when the risk of disrupted balance falls within the predefined and tolerable organizational and legal limits in compliance with the rules of social existence". The development of the model which allows to set and control such norms constitutes an interesting, yet complex research issue. Petrenko formulated a synthetic method of security measurement by defining the national security indicator in the following manner [6]:

$$Z_{general} = \sum_{i=1}^3 \alpha_i z_i \quad (1)$$

where:

$i=1,2,3$ - number of basic security area, which includes:

- $i=1$ - natural-ecological area;
- $i=2$ - technogenic-industrial area;
- $i=3$ - antropogenic-social area;
- α_i - weighing coefficient for the i -th basic security area;
- z_i - security indicator for the i -th security area;

The security indicator for the i -th security area may be set using the following correlations (2):

$$Z_i = \sum_{j=1}^{m_i} \beta_{ij} y_{ij} \quad (2)$$

where:

- m_i - quality coefficient for z_i security indicators
- $j = 1, m_i$ - number of integral level of security;
- β_{ij} - weighing coefficient for the j -th integral security coefficient;
- y_{ij} - security coefficient for the j -th integral level of security;

The above-mentioned definitions were constructed in such a manner so as not to narrow the domain for risk differentiation. At the stage of basic study, the approach is fully justified, as any kind of groundless limitations would pose threat to the national security. However, when it comes to a specific goal formulated in the previously described manner, it is necessary to use a different approach. When assuming that the logic of correlations according to the general definition is a limitation, it is essential to expand the correlations so

that the problem becomes countable. Therefore, the definition of the economic security must specify the problem to allow its strict modeling.

According to the source literature, the opinion that the broadly defined national security should include the following is predominant [7-11]:

- military security,
- political security,
- economic security,
- security of public order,
- security of state apparatus,
- security of international relations,
- cyber security.

As part of the economic security, the following may be distinguished (Fig. 2):

1. security of financial turnover and external financing,
2. security of budget (of a country and local governments),
3. security of economic information,
4. secure availability of means necessary to maintain production and supply.

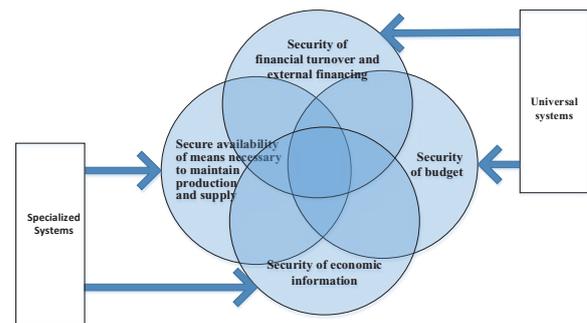


Fig. 2. Economic security

To ensure economic security, it is necessary to ensure all elements of the appropriate functioning of the country's economy. In each of the four cases, the problem is related to availability:

- cash (at all levels of the functioning of the country),
- information,
- means necessary for the functioning of the society and production.

The inter-linkages between particular areas of economic security are shown in Fig. 3.

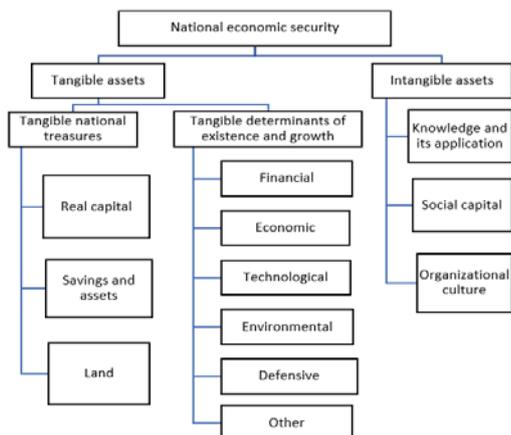


Fig. 3. Tangible and intangible assets to ensure the national economic security [12]

The subject of the article is economic security and, more precisely, its area that covers secure availability of means necessary to conduct business activity and protect the life of citizens. Bearing in mind such limitations, it seems justified to propose, for the purpose hereof, the following definition of the national economic security: the national economic security is the ability of a country to control and shape availability of specific means so as to prevent deterioration of its economic results. The source literature contains many propositions of the catalog of "means". The popular type of availability refers to:

- food,
- raw materials,
- all energy carriers,
- apartments,
- drinking water,
- medicines,
- transport.

In accordance with the thesis formulated by Księżopolski [4]: "... *The typology is open: it is not a classification meaning that the national economic security would face new risks meeting the criteria of negative impact on the values constituting the economic security. Such an approach is justified by high changeability of social life, among other things, due to dynamic globalization process...*", exhaustive closing of the potential catalog is not the most important matter at the stage of the choosing the first approach to practical solutions. It is necessary to choose potential means from the catalog, which shall be the subject of the first solutions (applications). There is no reason not to gradually expand the list in further steps. Such freedom of action is possible due to the fact that the chosen method is practically independent of the type of the selected mean and may be repeated. However, it is still necessary, from an objective point of view, that the future user (i.e. in this case, competent state authorities) made formal decisions in the process regarding the scope of implementation. According to the proposed decision,

some links between the budget and national statistics shall exist. Depending on the adopted decisions, the activities undertaken to solve the problem shall have to be reorganized. The list of "means" should also include (which does not have to seem evident) social involvement to maintain the established level of security. The society is both the producer and final recipient of the necessary means. After all, the national security is the security of citizens. Therefore, it is the decisive factor, even though often neglected, which determines the maintenance of appropriate level of security. However, such issue (sometimes considers a part of the political security or public order) requires different methodological approach and separate decisions of competent authorities. In case of the discussed issue, the models should be constructed in a spiral manner and their stages gradually implemented by the team (internal procedure) composed of the employees of the user and external specialists. The above-mentioned approach allows to gradually adapt the system to the future work realities. Additionally, it allows to freely adjust the preliminary requirements and gradually verify efficiency of the operations within the selected scopes. In this case, due to a possibility of:

- working verification process,
- practical use of the results at particular stages,
- basically unlimited upgrade and improvement of the system,

such structure of the model seems to be the best. While considering the fact that economic aggression is now increasingly used and considered efficient method of acting to the detriment of the so-called "enemy" countries, the issue of the national economic security becomes an urgent matter due to basically non-existent advancement of practical applications. By expanding the previous definition of the economic security, the issue of correlations as resulting therefrom with respect to the availability of means affecting the national economic security is shown in Fig. 4.

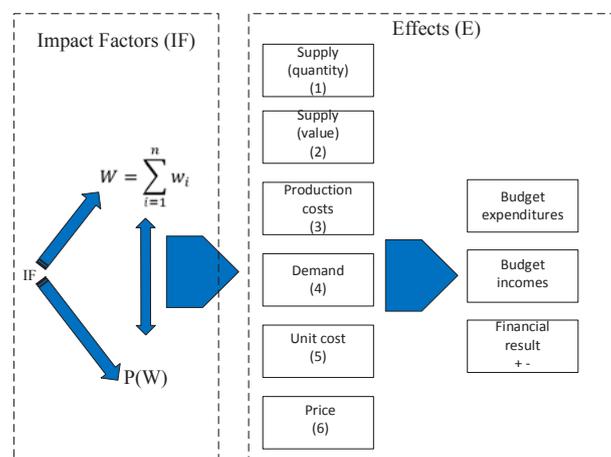


Fig. 4. Assessment of material means affecting the national economic security

Where :

W – the total amount of the production of specific means material for the economic security

i=1..n – the production plants producing specific means material for the economic security

P(W) – the short- and the long-term forecast of the production of specific means material for the economic security

IF – the impact factors shaping the production capacity of the means material for the economic security.

Each of the items from 1 to 6 marked in the figure includes: Production, import, export and inventory. The correlation shown in schema 1 is the correlation between "IF" impact factors and effects "E". The "IF" impact factors should include the following:

- following year n+1 (whose budget is prepared), and factors affecting its feasibility are initially recognized (signaled)
- year n+2 (preceding the year, for which the budget is prepared), and trends of changes in factors affecting such year are noticeable.

The information about "IF" is not directly available. To obtain such factors, it is essential to search a large number of data. The sets of received data shall also be quite expensive. To obtain the necessary information, it seems justified to use the "Big Data" technology. On the other hand, the "S" effects are values strictly defined and relatively easily accessible in the prepared statistics (items 1-6) or potentially easy to calculate (items concerning the budget). What is more, the number of such factors was also reduced to the necessary minimum in the presented proposal. The problem is to find a method for determining which "W" impact factors contribute to the change of "E" effects. If the trends were unfavorable for the economic security, it would be possible to implement appropriate remedial measures, at the stage of budget planning (year n+1), to eliminate or mitigate the risk of economic security. The concept requires planning of budget simultaneously for two periods – year n+1 and n+2. The TREND function, shown in Fig. 5, used in the system dynamics described by Sterman [13], is in line with the method of budget forecast.

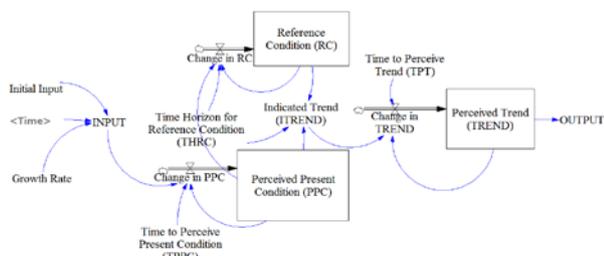


Fig. 5. Use of the forecast TREND function to plan budget [13]

The presented TREND function allows continuous process of control and adjustment of the forecast values with respect to the data collected on an ongoing basis. The function may not be used to forecast any values of the budget components in different time horizons. The process of stabilizing forecast input values depending on the adopted forecast period is shown in figure 6.

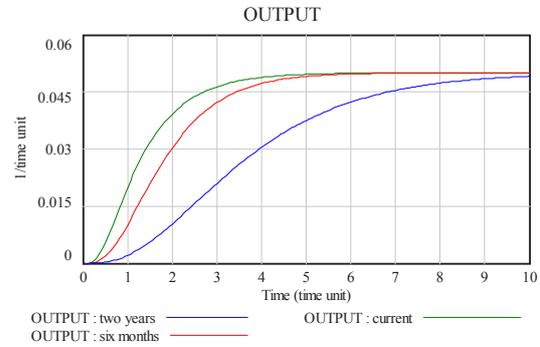


Fig. 6. Stabilization of forecast values depending on the forecast period

As the figure shows, longer forecast horizon makes it necessary to apply longer period of the analyzed deviations. It proves that the use of the forecasts up to two years in advance is justified. Currently, it is not required in Poland to prepare budget forecast for the year n+2. Pursuant to Article 222 of the Constitution of the Republic of Poland, the Council of Ministers is only obliged to submit with the Sejm (the lower chamber of the Polish parliament) draft budget act for the next year, 3 months prior to its beginning. If the introduction of an obligation to prepare budget forecasts for the year n+2 was an internal issue of the Council of Ministers, a resolution passed thereby would be sufficient to settle this matter. Therefore, it would not be a complex legal issue. Much more difficult in legal terms would be to obtain the necessary information from international corporations.

4. Diagnostic model of economic security

In the outlined diagnostic model of economic security, two main areas were distinguished: availability of means and financial security. The first area was extensively discussed in the previous chapter. The issue of financial security was included in detail in the universal systems operating in every country. The issue is supervised by a number of state institutions such as: ministries of finances, central banks, financial supervisions authorities and special services. However, some aspects, in particular those related to security, may not be omitted due to specificity of the subject matter of this article. The financial security (FS) expressed in quantities may be calculated according to the following formula:

$$FS = \sum(a_{ext} + a_{nat}) - \sum(p_{ext} + p_{nat}) \quad (3)$$

Where:

- FS – financial security
- a_{exte} - external assets
- a_{nat} - national assets
- p_{ext} - external liabilities
- p_{nat} - national liabilities

The model of correlations between the factors shaping financial security is illustrated by way of the Casual Loop Diagram (CLD) in figure 7.

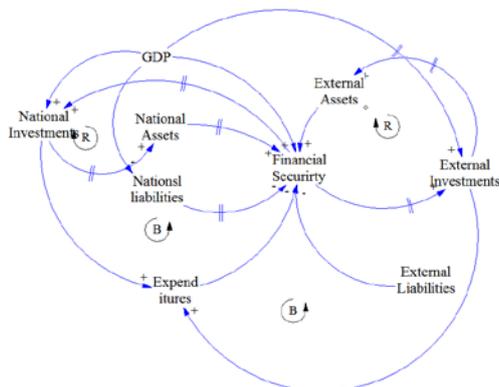


Fig. 7. CLD (Casual Loop Diagram) for factors shaping financial security.

The diagram shows four casual loops: two reinforcing loops between the increase of financial security and tendency towards national and international investments, and two balancing loops between the investments and expenses, which contribute to the decrease of financial security at least within a short period of time. Assuming that there are no delays between particular events, the curve showing financial security with respect to time is illustrated in figure 8.

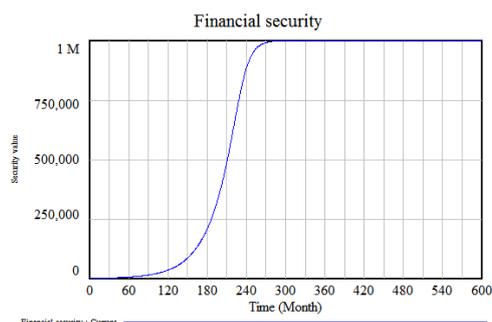


Fig. 8. Financial security curve

However, some delays occur in casual loops and have impact on the shape of the curve representing financial security. After a certain period of time, the curve may take the form of an oscillator, but once the delay threshold values are exceeded, the curve may become more chaotic. In case of model calibration, both upper and lower limits for such delays should be established so as to prevent chaotic behavior of the modeled variable. While modeling financial security, attention should be paid to the GDP (Gross Domestic Product) variable, which has its own dynamics of changes. The

GDP variable was modeled by Sterman [13]. CLD showing the GDP variable is shown in figure 9.

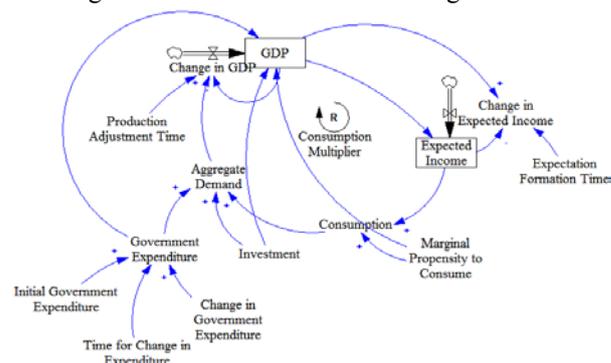


Fig. 9. CLD for GDP variable [13]

Upon initial calibration of the model, the curve for the GDP variables looks as in figure 10. According to the figure, after a certain period of time, the value of the variable stabilizes at a given level, which means that the variable should not cause chaotic shaping of financial security.

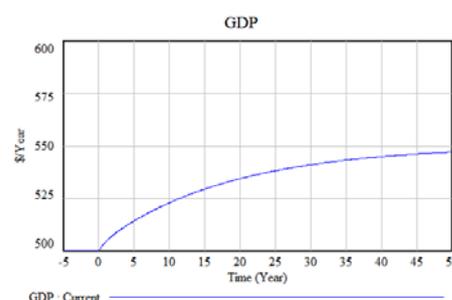


Fig. 10. Chart showing shaping of the GDP variable over time.

Apart from financial security, the second factor that has impact on the national economic security is availability of strategic means. The factors are described in chapter 3. The general diagnostic model concerning availability of means is illustrated by way of CLD in figure 11.

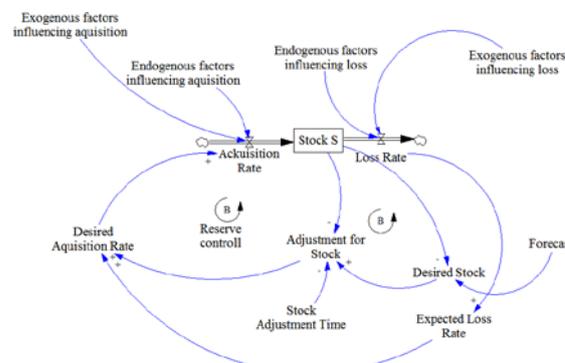


Fig. 11. CLD for availability of means. Own elaboration on the basis of [13]

Two balancing loops concerning the control of inventory and desired level of inventory are show in

the diagram. In such case, the curve showing the level of inventory runs as illustrated in figure 12.

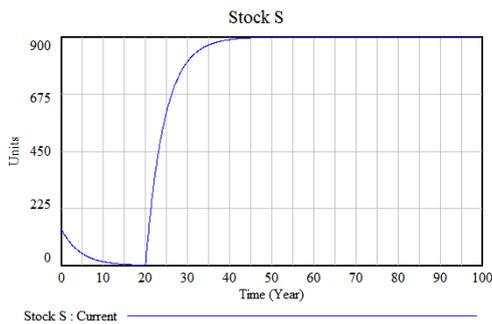


Fig. 12. Chart showing shaping of the inventory variable over time.

The main problem in case of this model is to answer the question when does the variable stabilize. It depends to a large extent on endogenous and exogenous factors having impact on the obtaining and use of given means, whereas each S mean has a different set of such factors. Therefore, the model calibration shown in figure 11 requires development of models for assessment of endogenous and exogenous variables having impact on the obtaining and use of means critical for the national economic security. Due to the process complexity and large number of variables, it seems necessary to use the Big Data technology to obtain all the necessary data. Cholewa and Kościelny [1] point out that while constructing diagnostic models, it is especially useful to apply artificial neural networks. Therefore, it is worth considering the use of such a technique for building the analytical model.

5. Conclusion

All issues of the national security or its separate strategic parts need to be treated in a highly responsible manner. No mistakes should be allowed while making decisions on the above-mentioned matters. The comparison of results of assessments made on a macro scale and with respect to separate events allows to mitigate such risk and improve versatility of assessment. Therefore, both approaches were outlined in the article. In the second case, it was suggested to adopt the level of availability of means as an assessment criterion. The issue of availability of means was analyzed as a separate problem of financial security. Precise calibration based on the actual data is essential for practical application of the proposed model. Since there are delays within the area of the located casual loops in the outlined financial security model, it is important to determine the values of such delays and assess threshold values so as to prevent chaotic behavior. While calibrating the model for control of availability of strategic means, it is crucial to

precisely determine the value of endogenous and exogenous variables having impact on the obtaining and use of the particular means. It requires the construction of a separate model, which constitutes an interesting starting point for further research.

6. Bibliography

1. Korbicz J., M. Kościelny, Z. Kowalczyk, W. Cholewa, *Diagnostyka procesów: modele : metody sztucznej inteligencji : zastosowania*, Wydawnictwa Naukowo-Techniczne, (Warsaw 2002).
2. J. Gołuchowski, *Inteligentne systemy diagnoz ekonomicznych*, Akademia Ekonomiczna im. Karola Adameckiego, p. 37, (Katowice 1997).
3. Emory W., Niland P., *Making Management Decisions*, Mifflin, Houghton, (1968).
4. K.M. Książopolski, *Bezpieczeństwo Ekonomiczne*, Dom wydawniczy ELIPSA, (Warsaw 2011).
5. K. Raczkowski, *Bezpieczeństwo ekonomiczne. Wyzwania dla zarządzania państwem*, Wolters Kluwer, (Warsaw 2012)
6. I.N. Petrenko, *Security Essentials of functioning businesses*, Ankil, p. 56-58, (Moscow 2006)
7. K.A. Wojtaszczyk, A. Materska-Sosnowska, *Bezpieczeństwo Państwa*, ASPA-JR, (Warsaw 2009)
8. T. Skrypko, *The Role of Entrepreneurship in the Economic Security of the State*, Ovidius University Annals, Series Economic Sciences, Vol. 13 Issue 2, p. 509-513, (2013)
9. I. Chistnikova, M. Antonova, S. Yakimchuk, *Indicators and mechanism to ensure economic security of the regions*, Regional Science Inquiry, pp97-105 (2017)
10. M.Redo, P.Siemiątkowski, *Zewnętrzne bezpieczeństwo finansowe państwa*, Uniwersytet Mikołaja Kopernika w Toruniu, (Toruń 2017)
11. A. Jackiewicz, A.Trzaskowska-Dmoch, *Bezpieczeństwo ekonomiczne państwa : uwarunkowania, procesy, skutki*, CeDeWu, (Warsaw 2017)
12. D. Ćwikowski, *Gospodarka nieoficjalna a bezpieczeństwo ekonomiczne państwa*, CeDeWu, (Warsaw 2016)
13. Sterman, J., *Business dynamics : systems thinking and modeling for a complex world*, Boston: Irwin/McGraw-Hill (2000).
14. M. Kiedrowicz, *Dynamic business process in workflow systems*, MATEC Web of Conferences, vol. **125**, DOI: 10.1051/mateconf/201712502014 (Greece 2017)