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OWNERSHIP RIGHTS ON INTERMEDIATED SECURITIES

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ABSTRACT

The article is devoted to the contemporary problems of the ownership rights on intermediated securities. Authors study ownership rights as well as reviews the models of the proprietary rights in the modern holding chains and models of the securities holding systems, such as direct, indirect and mixed. Then author reviews the multi-tiered system of intermediation holding and proprietary rights in it under the discourse of the Latvian law, which stays on the position of the individual ownership model. This model contemplates that the end-investor has complete ownership on the securities and argues that ownership rights on intermediated securities, which are confirmed by the intermediary to the end investor under Latvian approach is a current legal fiction.

Objectives: The study aims at continuing development of the securities law theory, while its task is to characterise the ownership rights on intermediated securities from the point of view of Latvian law and practice.

Methods/Approach: Scientific research methods – both comparative and analytical – is used in the process of drawing up of this article.

Results: Authors come to conclusion that the scope of the rights confirmed by intermediary is narrower than scope of the “classic” legal ownership rights.) as well as states that the type of account is the additional attribute which allows to determine the status of the proprietary rights on securities entered in. The legal fiction of the “ownership” on intermediated securities is created to eliminate too complex descriptions of underlying rights and to simplify the description of the transaction, applying clear and understandable simple structures such as sale purchase or repo.

Keywords: securities, ownership, intermediaries, repo, Latvia

JEL classification: K11, K15, K22

Paper type: Research article

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INTRODUCTION

The authors believe that it is difficult to imagine situation when somebody is confirming ownership rights to third person without understanding of the nature of the confirmation and volume of the rights which are confirmed. Thus, the importance of the article could be explained with insufficient attention paid and scientific research undertaken in particular on the subject of securities law, its content and contemporary legal understanding of the existing processes. The article is part of the Tatjana Jukna’s dissertation and contribution of the authors in the project “Quadruple Helix Concept as Base of Sustainability via Next Generation PPPP Model Know-How”.
The purpose of the article is to clarify the essence of certification of ownership rights on intermediated securities by financial institutions, simultaneously developing securities’ law theoretical justifications which could help to resolve practical issues in future. The study aims at continuing development of the securities law theory, while its task is to characterise the ownership rights on intermediated securities from the point of view of Latvian law and practice.

METHODOLOGY
Methods and materials: methods used to achieve the aims of the study are comparative and analytical methods of scientific research. Materials of the studies consists of analysis of law texts, scientific articles and publications, as well practical experience gained in the topic of the research.

DISCUSSION AND RESULTS
Ownership rights on intermediated securities
Contemporary opinion about nature of securities from the point of view of the investor\(^1\) states that securities is, on the one hand, a personal right of the investor against the issuer of the securities, a kind of contract, and on the other hand, it is an asset or property of the investor (Alferez, 2006), (Donald, 2005). Thus, the question of an investor's personal rights is an object of corporate law, and, in turn, proprietary rights are an object of civil law governing proprietary relationships.

The word “securities” in Latvian means ”vērtspapīri”, which can be translated literally into English as valued papers. This Latvian word itself indicates the historical characteristics of the formation of securities, namely, the historical issue of securities in paper form.

This issuance of securities in paper form has created a legal fiction in which intangible things (the rights and obligations of the issuer) have been attached to tangible thing - a specific document, namely incorporated into it. At the same time, such a legal fiction also has legal consequences. The main function and purpose of such attachment when creating a new legal fiction was to simplify circulation of securities (their purchase and sale) as a thing of material world, tangible asset. At the same time a bona fide purchaser relied on physical possession of a thing (security) with which non-material personal rights were assigned (Alferez, 2006).

“Legal fictions prove indispensable in connecting the law’s familiar experiences and its conventional knowledge with these unanticipated human events to attain an outcome that is most congruent with what society understands its legal system to be” (Boyte, 2014).

In the digital age, the physical papers have been replaced by an electronic record to speed up circulation of securities and to avoid necessity of physical delivery of the papers. In essence, one fiction has been replaced by another fiction, although the essence of the record has not changed, rights are still incorporated into it. The electronic record is an electronic code or a set of impulses.

\(^1\) The words “investor”, or “end-investor” are used in the meaning of account holder who is not acting as account provider of someone else.
Previously, the transfer of ownership of a security required a) a contract - the security itself, which incorporated the rights and obligations of the issuer and b) a physical transfer of the security (Alferez, 2006). Assuming that an entry in an electronic register constitutes a contract between an issuer and an investor, the transfer of such an entry constitutes the transfer of a security. It should also be noted that the electronic record itself is not transferred anywhere and when an operation is carried out one record is deleted and a completely new digital code is created, i.e. the external graphic image remains, but the new electrical signals are created, in other words they are replicated and the same code is not transferred. Thus, the major difference between securities in paper form and securities in the electronic form is the absence of the continuity of the electronic record: when ownership rights on paper securities was transferred, the physical transfer of security occurred, but when ownership rights on electronic security occurs, new replica of record is created.

What this replica means? It means that record is not passed. But if securities are the record with incorporated rights, then record should be passed, otherwise record is not security anymore. All these thoughts allow come to conclusion that electronic record does not incorporating personal rights on securities anymore. Personal rights on securities exist by themself, but they are closely connected with proprietary rights, and are virtually attached to the personality of the owner of proprietary rights as it was agreed for the purposes of European Securities law – “rights flow from securities” (European Commission, 2011). In other words, record is evidencing proprietary rights. The record in the form of various replicas could be reflected as on accounts of various intermediaries, as on account of the end-investor, who should be recognised as legal owner. It means that should be at least one more attribute, which allows to distinguish unambiguously between holding and ownership. While, the records are made in the accounts, it means that the type of the account must be considered as such attribute. As per author’s more than 20 years practical observation, when working with various jurisdictions the following classification of accounts could be provided:

(a) **Nominee account** is account in which ownership on securities is registered in the name of the trustee, who later confirms beneficial, equitable interest in securities (FATF, 2009).
(b) **Omnibus account** is account in which securities of various investors are held.
(c) **Nominal account** is account which could be used as individually segregated account to held securities of one certain investor, for example Alternative Investment Fund, as an omnibus account.
(d) **Proprietary account** is account in which securities which belongs to one investor are held.

For a more detailed understanding of the specifics of the registration of the ownership, it is helpful to consider the specifics of holding of intermediated securities because modern public trading requires securities to be in dematerialised (book-entry) form, and could be held through long chain of intermediaries, as it is illustrated in the Figure 1.
Models of the proprietary rights on securities in the modern holding chains

In general, there are various concepts regarding the holding and ownership of intermediated securities in world practice. For example, International Institute for the Unification of the Private Law Legislative Guide (UNIDROIT, 2017) identified various general models of holding systems. These models in general are very similar, but they reflect variations on proprietary rights in securities, legal relationships between account holders (investors), intermediaries and central Securities Depositories. Sometimes it is difficult to evaluate to which concept belongs existing system. Money (2019) indicates following models:

(a) *individual ownership model*, which contemplates that the investor has complete ownership on the securities registered in the account (France), neither CSD neither intermediary have interest in securities.

(b) *co-ownership model*, which contemplates that investor has co-ownership of his share of pooled securities held in CSD, which issued certificated on securities held with him. (Austria, Germany).

(c) *trust-model*, which contemplates those participants of the CSD are legal owners of the securities, participants act as trustees for the investors. Thus, investors are trust beneficiaries and have beneficial, equitable interest in securities. (Australia, England and Whales).

(d) *security entitlement model*, which contemplates that every account holder in the holding chain, including participants of CSD, acquires securities entitlement. “A security entitlement confers *sui generis* rights against the relevant intermediary and to the securities held by the intermediary. Account holders (“entitlement holders”) do not have direct rights against the issuers of securities” (Money, 2019) (Canada, United States).

At the concept of the securities entitlement new legal fiction has been created, i.e. the intermediary confirms an entitlement on the pool of the securities being in its possession (securities entitlement), which is called financial assets (UCC §8-102 (9)). “A security entitlement is a package of rights less then ownership on underlying financial asset” (Chun, 2012). Although the investor operates with this right as a he would have ownership when carrying out transactions. The above statement is true for any model of holding of proprietary rights. The legal distinction as to consequences only arises at the time of a shortfall of securities (insolvency of the intermediary or other negative event), when the investor, depending on the type of US intermediary, is returned either the securities in *pro rata* to their availability, subject to the rights of other investors with respect to a specific pool of securities, or compensation in the same *pro rata* amount.
The concept of securities entitlements is more developed in the systems of the common law (especially in US), as states Steven L. Schwartz despite the different models of holding investors are in the similar position when English model is applied; “investors enjoy proprietary interests in securities under trust and co-ownerships arrangements, technically, equitable tenancies in common” (Schwartz & Benjamin, 2002).

Therefore, in civil law jurisdictions the position of the law is not so clear in the absence of the special legislation. It should be noted that the Latvia belongs to the civil law jurisdictions and there is no positions and publication regarding problematics of the ownership rights on intermediated securities, but author believes, that Latvia belongs to the individual ownership model due to the absence of any other specific regulation except for provided in the “Financial Instrument Market Law” (Finanšu instrumentu tirgus likums, 2003).

As it follows from mentioned above no clear ownership rights in the classic meaning of these word, subject to individual ownership model, are confirmed to the investor, who believes to have proprietary rights – ownership on securities. The problematics of the individual ownership model in respect of intermediated securities will be reviewed in this article later.

Understanding of the ownership rights or the legal status of the securities could impact not only on transactions (the deeper understanding of their nature, as for example in the case of repo transactions), but on investor protection also, as well as on obligation of the intermediaries toward to the investors, especially when shortfall in securities occurs in the chain of the intermediaries, and securities are held by intermediary in accordance with instruction of the customer. The absence of the uniform understanding regarding classification of intangible assets as securities or claim rights (for example securities entitlement) creates uncertainty of relationships between investors and intermediaries.

Models of the securities holdings systems

In common 3 general types of the holding system exist, all others are variations: Direct holding system, indirect holding system and mixed holding system.

Direct holding systems

The system of direct holding of securities implies the creation of a centralised register (Central Securities Depository) (some analogue of a Land register) in which both the fact of issuance (the contract with the issuer) and the number of issued securities are recorded. The name of the investor at any given time is known to the CSD (Fei, 2021), because intermediaries, who are CSD participants open accounts in the name of each investor and there is a clear connection between the issuer and the securities belonging to each particular investor, on the level of CSD or participant. Under such concept of the holding, only the person registered in the register is recognised as the legal owner, and this person holds title on securities. In direct holding systems the names
of investors (legal owners of securities) are known to the CSD. A direct holding system recognises no nominee accounts and no right to share co-ownership on a pool of securities. Thus, the contract and the ownership of the record are closely linked, and it is possible to trace all records. Intermediary fills the function of the agents or attorney who represents investor, some kind of account operators. (see Figure 2). This model from the perspective of investor’s proprietary rights is clear individual ownership model.

<table>
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<td>Issue of securities 1 (100 (1)+150 (2)+200(N)….+30(Z)</td>
</tr>
<tr>
<td>Investor 1 100</td>
</tr>
<tr>
<td>Investor 2 150</td>
</tr>
<tr>
<td>Investor N 200</td>
</tr>
<tr>
<td>Investor Z 30</td>
</tr>
<tr>
<td>Participant, operator of the Investor’s account</td>
</tr>
<tr>
<td>Participant N</td>
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Figure 2. Direct Holding Model  
*Source: author’s illustrations*

This model from the perspective of investor’s proprietary rights is clear individual ownership model. The traceability and transparency of the records exists. The model is clear and understandable from the point of view of the corporate law. In this model CSD participants is conducting the function of the Intermediary operator of the account of the investor. It should be noted that under direct holding model CSD sees the exact number of the securities which belongs to each investor.

Such countries as UK, Spain, Scandinavian countries have developed centralised investors (shareholders) registration systems distinct from securities account systems, but other European countries, such as (Germany, Italy, France, Italy, Portugal, Latvia, Lithuania) (European Commission, 2011) where securities account system contributed to the identification of the shareholders. Countries, which has no centralised investors registration systems, usually uses Indirect holding System or Mixed holding system.

*Indirect holding systems*

In the indirect holding systems, the register (Central Securities Depositary) keeps information about the issuer, the number of issued securities, as well as information about securities owned directly by the participant (intermediary) and information about the securities being in a nominal holding of the participants (described here as a general case). Intermediaries, on the other hand, register the proprietary rights of the particular investor on certain securities in their (intermediaries’) books, accounts opened for each customer. As said Steven L. Schwartz “in an indirect holding system an issuer of securities generally records ownership of its securities as belonging one or more depository intermediaries” (Schwartz, S. & Benjamin J., 2002). This statement could be as correct as an incorrect, because for example in the trust model, intermediary participant is legal owner, and his securities are held on the nominee account, this statement is correct, but when securities are held on the nominal account (*nominālais konts*) he does not became the owner, he is only holder of the securities, and issuer can record that intermediary holds securities for investors. In other word, in the indirect...
holding system intermediaries play an important role, they not only hold securities of the investors and know their names for the purpose of realisation personal rights virtually attached to every security, but they also confirm proprietary rights of each investor. For the indirect holding model please see Figure 3.

![Figure 3. Indirect Holding Model](source: author’s illustrations)

The systems of indirect holding recognize not only proprietary accounts, but accounts which differentiates the ownership status of securities held on them.

Mixed holding systems

In the Mixed Holding Systems, the register (Central Securities Depository) keeps various types of accounts proprietary accounts as for participants as for investors, as well as nominal accounts of participants intermediaries. Intermediaries -participants conducts the function of operators or agents of such investor’s proprietary account. The Figure 4 illustrates mixed holding model.

The model of the mixed holding system is laid down in Europe with Central Securities Depository Regulation (Regulation No 909,2014) (thereinafter - CSDR) and its later amendments. CSDR regulation is binding to Latvia as the EU Member state.

![Figure 4. Mixed Holding Model](source: author’s illustrations)
Investor 1 opened individual account as customer of Participant 1 – Intermediary, the as it is shown in the figure 4 “Mixed Holding System”. Intermediary operates this individual proprietary account of the intermediary, ownership rights for such segregated individual proprietary account confirms central Securities depository, therefore nothing is preventing the Intermediary to reflect securities directly registered with CSD, together with other securities held in portfolio in favor of the customers with other intermediaries (banks, investment brokerage companies and etc), when securities are held via longer chain of intermediaries (multi – tired intermediation).

**Multi – tiered intermediation in holding of securities**

When intermediated securities are hold within one jurisdiction, the law of only one jurisdiction applies, it means, that in such chain of the holding shouldn’t arise any discrepancies in relation of the ownership rights on securities or volume of the rights which belongs to the investor, especially, for example when securities entitlement model applies. But when overseas securities (from the perspective of the place where investor’s account is opened) are registered in the account, multi-tiered chain usually exists, and future it is not possible to answer on the question about type of rights which belongs to the investors. The problematic of ownership rights in multi-tiered intermediation holding will be reviewed later, in the separate chapter.

Multi -tired intermediation are reflected in the Figure 5 “Multi-tiered holding”. What means multi-tiered holding? It means that every intermediary in the chain confirms rights on the securities for the lower lever intermediary, without any knowledge of the identity of the end-investor (securities owner) at the certain moment, and in cases when lower-level intermediary must disclose information on the identity of investor (for tax purposes or corporate events), must rely on information provided by lower-level investor. The longer the chain, the less reliable information is provided, the more difficult to give the ultimate investor the opportunity to exercise the personal rights he or she has as a shareholder, for example to vote in a corporate meeting by expressing his or her opinion. It should be noted than the length of the chain is not limited.

![Figure 5. Multi-tiered holding](Source: author’s illustrations)
Summarizing mentioned above we quite easily may come to conclusion that: (the law of every certain jurisdiction, where intermediary is registered will apply at the certain level of holding. It means that ownership rights on any other rights in respect of securities are subject to the law of every jurisdiction. It is very important point for the future analysis, from the point of Latvian law.

**Ownerships rights on intermediated securities under Latvian law**

Latvian Civil Law (Civillicums, 1937) does not recognise beneficial\(^2\) or trust ownership (Grasis, 2008), but however the relationship similar to the trusts are widely used in the financial sector. For example the concept of nominee account (*nominālais konts*) or account for holding of securities which belongs to the customer’s of intermediary are implemented throughout part 1 of the 130 of the Financial Instrument’s Market Law: “…The account in which the registered financial instruments are financial instruments held by a person shall be identified as a nominal account.” What is important, in this regard: When securities are held on nominal account the intermediary does not become the owner of the security, he is only its holder. It is important from the perspective of intermediated securities because this statement of the law clearly distinguish concept Latvian holding concept from the trust model of the holding. Moreover, securities are segregated from the own assets of the intermediary not only in the balance sheet of the intermediary, but in the accounts (nominal and own). It should be noted that the nominal accounts contain securities belonging to several investors at the same time and therefore the intermediary confirms the ownership to many investors in the quantitative proportion of the bundle of securities on the nominal account, proportionally to the number belonging to each investor\(^3\).

Regarding ownership rights on securities the Financial Instrument Market Law avoids using the word “ownership”, the part 1 of the article 125 “Rights to the Financial instruments” states: “Financial instruments belong to the acquirer thereof from the moment they are registered in the financial instrument account of such acquirer.”, but later in the article is stated, that “… entry in the financial instrument account of the person […] shall be a proof that financial instruments are owned by aforementioned person”. Therefore, it allows to conclude that the Latvian law:

(a) Recognizes the securities account owner either as owner of the securities registered in the account ether as holder of securities, assuming that securities are owned by the customers of the intermediary (end-investors).

(b) Entry is the proof that securities belong (are owned or held) to the account holder.

(c) The type of the account is the attribute which allows to identify status of the rights to securities (ownership or holding).

\(^2\) However, for the sake of clarity it should be noted that the concept of beneficial owners as persons who receive an economic benefit has been introduced into Latvian legislation in line with international anti-money laundering trends and subsequently incorporated into commercial law for the purpose of disclosing the beneficial owners of companies. However, civil law does not recognise the concept of beneficial ownership.

\(^3\) therefore it is not exclude possibility to open the account with other intermediary and separate individual assets of the customer.
(d) Latvia belongs to the individual ownership model.

In other words, intermediary acting under Latvian law confirms ownership rights, but in reality, it is entitlement on the securities as it is implemented in the indirect holding concept existing in US law, because factual situation is the same: accounts, securities and segregation on nominal (omnibus) accounts for all investors, later the intermediary makes the book-entries on the individual accounts of each investor in own record keeping system. Investors has no rights to claim intermediary of their intermediary, and may bring their claim only directly to their intermediary, securities account provider.

The system of indirect holding of securities involves the use of a chain of intermediaries, each of whom has been delegated the right to confirm ownership of, or to inform about ownership of certain rights in securities. This delegation essentially derives from the right to open and maintain securities accounts in the ordinary course of the business and, as a consequence, to register securities on the account in book-entry form, thereby confirming the ownership of securities within the framework of the license granted by the supervisory authority. It should be noted that in accordance with article 3.4 “Law applicable to the Financial instruments” of the Law on the Markets of Financial Instruments the following general principle is applied “the law of such country shall be applied […] in which the operator of the relevant account […] has been registered.” The law registration of the intermediary applies to all activities of the last, including to the recognition of the investor’s ownership (legal status and belonging of financial instruments). Therefore Latvian law at the same article recognizes that in the chain of the intermediaries the laws of various jurisdictions shall be applied to the each level of the holding: “If financial instruments are kept with the intermediation of several operators of the accounts or registers of financial instruments, the law applicable to points of law in relation to such financial instruments shall be determined individually for each account or register of financial instruments in which such financial instruments have been recorded.”, but international private law applies on the higher tiers, on the tier of the Latvian account providers Latvian law will apply, and Latvian intermediary will attest the ownership rights of the end-investor on the securities. What it means? It means that in the situations when various intermediaries are involved in the chain, each of them will treat rights on securities under it local law and ownership holding system, for example as it is reflected in the figure 6, in result confirming clear ownership rights on securities while in other holding systems co-ownership rights or other types of rights are confirmed.

For the better understanding of the legal situation with ownerships rights under applicable law C (Latvian law), the ownership rights during all chain of the holding are analysed. Customer I2 is the bank registered in Latvia, which maintains an accounts for 3 customers, two of them are end-investors, but third Latvian broker, for whom nominal account is opened. Latvian Intermediary (Customer I2) and Latvian broker (Customer I3) confirms ownership rights on securities to the end investors, in accordance with the law of Latvia, as if Investors 4-6 would legal owners of securities, but in accordance with the law A Participant 1 is the legal owner of securities, all lower tiers hold beneficial equitable interest, and Participant 1, confirms to the Customer I1 only beneficial equitable interest in securities. Customer I1 holds 700 securities in the pull for.
various customers. He confirms entitlement on the financial assets, not beneficial equitable interests in securities in accordance with own law B. The volume of rights confirmed by him to each investor is less, that the volume of rights confirmed to him by Participant 1.

Figure 6. Ownership rights in the intermediated holding

Source: author’s illustrations

In other words, the nature of the rights which confirms Customer I3 (Latvian broker) to his customer investor 6 under analysed holding chain, as ownership rights is rights on pro rate securities entitlement on beneficial interests in securities. This is widely recognised principle of nemo *dat quod non habet* “one who has not cannot give” (Schwartz & Benjamin, 2002). When applying this principle to the intermediated securities, intermediary could not give or confirm more ownership rights that investor would have if he would on the upper tier of the securities holding chain.

In fact, the confirmation of ownership in the discourse of the Latvian Capital Markets law is a new legal fiction⁴, which is created to avoid digging deeper into the essence of the existing legal relationship. And with respect to such a fiction, securities sales transactions are concluded by transferring the rights as described above to the acquirer.

When new fiction is created, we are trying to use existing words, terminology, therefore the meaning and the essence of these words as in the case of the ownership rights confirmed by intermediary differs from the meaning and essence of the rights confirmed by another intermediary.

Contractual basis for the confirmation of the ownership rights exists in all systems, but in the case of the direct systems or direct individual account opened in central securities depositories, the ownership is

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⁴ An assumption that something tur even though it may be untrue […] (Bryan, 2011)
confirmed by direct account statements from central depository, and later reconfirmed by intermediary in a statement from relevant account. The basis for such reconfirmation is delegation powers contained in the contract with intermediary, but the primary confirmation is the statement issued by register (depository) where legal title is registered.

In the indirect system an ownership rights are confirmed on the contractual basis, all previous statements issued by other depositories or intermediaries is only initial source of data which declares existence of the rights of the certain types over securities, without actual knowledge of the investor, customer of intermediary. Intermediary when confirming ownership rights to the securities acts very similar as he would act when confirming amount of money on the account of its customer.

A customer, ultimate investor, is saying ‘I have money on my bank account’, and it is also a legal fiction, because but in reality, in the discourse of the law customer holds claims rights toward to the bank, and bank when making payments do it via various assignments to other banks in the chain of the intermediaries. When investor is saying ‘I have securities’, but in reality, he has no securities, investor has the complex structure of the rights related to the certain securities and to realization of the rights “flowing from these securities”. An investor saying, I have securities, because intermediary confirmed ownership on them: he made account entries which describes securities and theirs’s amount.

The question is: why in the first case it is claim rights but in another ownership rights, claim rights also is the type of the property? The answer is simple: (a) money is held in the balance of the bank and bank is legal owner, in case of securities intermediary is not the owner and securities are held out of the balance of the intermediary (bank). In fact, concept of ownership rights is used to distinct both legal situations: claim in relation of the property of the third person and claim in relation of own property. (b) The securities must have the legal owner as the second part of the publicly announced contract with issuer, and this legal ownership must be confirmed at least on one tier of the intermediation holding, especially if the chain of the holding is ideal, and it recognises only end-investor as legal owner.

If the chain is not “ideal”, the essence of rights passed to the acquirer can undergo a transformation in result of the transaction due to the changes in the chain of the holding and application of the different ownership model: if for example investor 6 sells securities to investor 1, who becomes the owner of beneficial interest over 250 securities. This situation occurs due absence of the uniform understanding and concept of securities ownership. One legal fiction (securities by itself) arises necessity to introduce other legal fiction whether by creating new ownership model (for example -securities entitlement model), or when trying to avoid creation of the new legal fiction (as individual ownership model), recognizing ownerships in situations the volume of the underlying rights is narrower as it should be in situations of the standard ownership rights, thus creating new fiction of ownership. In reality, ownership rights on intermediated securities are reduced by the rights of intermediaries over securities in result of long chain of the holding. And this is the question of the intermediary risk involved to the chain of the holding.
CONCLUSION

Modern securities are issued in the book entry form. Record in the securities account of the investor is evidencing proprietary rights on securities, but by the nature it is not securities. The type of account is the additional attribute which allows to determine the status of the proprietary rights on securities entered in. There is no uniform approach to the understanding and confirmation of the ownership rights (legal title) on securities in the worlds. Various models are used.

Latvian law system stays on the position of the confirmation of the direct ownership rights on securities to the end-investors, i.e. direct ownership model is used. In result when operating with securities Latvian intermediaries confirms more rights to the investors than they hold in the intermediated securities, thus creating new legal fiction of the ownership on intermediated securities. When investors conclude acquiring or alienation transactions with securities they enter into transactions about this newly created fiction “ownership” on intermediated securities, to eliminate too complex descriptions of underlying rights and to simplify the description of the transaction, applying clear and understandable simple structures such as sale purchase and etc.

The intermediary risk as well as uncertainty of the ownership rights over securities will exist while the conceptual form of the securities will not be changed, for example on securities issued based upon DLT (Digital Ledgers Technology), when securities as digital code will be passed to the end-investor. Thus, the uncertainty of the ownership will not exist anymore. But this is the question of the near future.

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Conflict of interests
The authors declare no conflict of interest.
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MOMENT EQUATIONS FOR STOCHASTIC SYSTEM SPECIAL KIND AS INSTRUMENT IN APPLY PROBLEM

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ABSTRACT

In paper considered the method of constructing moment equations for random solution of systems of nonlinear differential and difference equations, the right part of which depends on the stochastic process. Torque equations are constructed in the presence of jumps in solutions. For a system of differential equations with random coefficients, the case when the heterogeneous part of the system contains random processes such as white noise is considered. The ideas of A.M. Kolmogorov and V.I. Zubov on the analytical definition of random processes have been developed. In particular, non-Markov processes are investigated, which are determined by systems of linear differential equations with a delay in the argument. With the help of stochastic operators, fundamentally new results were obtained for non-Markov random processes, from which the main known results for Markov processes emerge. Methods and algorithms of analytical determination of finite-valued and infinite-digit random processes are proposed. The methods of studying the behaviours of the matrix of the second moments of some important classes of stochastic systems of equations are given because many optimization problems are reduced to the minimization of such a matrix. The substantiation of difference approximation for solving some types of differential equations used for the numerical solution of problems is carried out.

Keywords: moments first and second order, white noise, differential equations, numerical solution

JEL classification: C60, C40, H30

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INTRODUCTION

In modern applied studies, probabilities models are widely used. Among such models, classes of systems of ordinary differential and difference equations are practically important, the coefficients of which are random processes. Therefore, the study of probability models led to the creation of various current directions in the theory of stability and the closely related theory of optimal control of random processes.
The theoretical foundations of sustainability research for systems of differential equations with random processes were initiated by A.M. Kolmogorov. In the future, the approaches of A.M. Kolmogorov developed in their works D. Bertrand, Ghichmann, V.I. Zubov, M.M. Krasovsky, V.S. Korolyuk, I.M. Stratonovich, Ito, A.M. Tikhonov, D.G. Korenovsky, V.B. Kolmanovsky, R.Z. Hasminsky, A.V. Skorokhod, I.E. V.Y. Valeev, G.M. Milstein and others. The works of most researchers are based either on the study of the Fokker–Planck–Kolmogorov type equation and the probabilistic properties of solving stochastic differential equations, or on the analysis of momentary equations followed by the application of O.M. Lyapunov’s methods.

The developed theoretical, methodological and applied recommendations of this dissertation make it possible to expand the modern mathematical apparatus for optimizing dynamical systems in conditions of uncertainty and conflict situations. In particular, a number of problems related to political technologies, and banking are solved.

**METHODOLOGY**


**RESULTS**

On a probabilise basis \((\Omega, \mathcal{F}, P \equiv \{F_t, t \geq 0\})\) consider the system of stochastic differential equations

\[ dX(t) = AX(t)dt + Bdw(t) \]  

With initial conditions \(X(0) = \phi(\omega), dw(t) = w(t, \omega)\) \([0, \tau] \times \Omega \rightarrow E\) — Winer random process, \(A, B\) — some matrices on dimension \(m \times m\), a \(\phi(\omega)\) — random variable with its distribution law \(F_\phi(x)\).

**Theorem 1.** The matrix of second order \(D(t) = \langle X(t)X^*(t) \rangle\) of strong solution \(X(t) \equiv X(t, \omega)\) system of equations (1) satisfies the equation

\[ \frac{dD(t)}{dt} = AD(t) + D(t)A^* + BB^*. \]  

The solution of the system (2) is based on the formula

\[ D(t) = e^{At}D(0)e^{A^*t} + \int_0^t e^{A(t-s)}BB^*e^{A^*(t-s)}ds. \]  

If \( \lim_{t \to +\infty} e^{At} = 0 \), then we obtain the value of matrix \(D = \lim_{t \to +\infty} D(t)\) from formula

\[ D = \int_0^\infty e^{At}BB^*e^{A^*t}dt. \]

**Proof.** 1 algorithm. The auxiliary system is considering

\[ \frac{dX(t)}{dt} = AX(t) + B\xi_\lambda(t), \]

here \(\xi_\lambda(t)\) — Markov process, with value \(\pm\sqrt{\lambda}\) and probabilities
\[ p_1(t) = P\{\omega: \xi(t) = \sqrt{\lambda}\}, p_2(t) = P\{\omega: \xi(t) = -\sqrt{\lambda}\}, \]

Which satisfied the system equations?
\[
\frac{dp_1(t)}{dt} = -\lambda p_1(t) + \lambda p_2(t), \quad \frac{dp_2(t)}{dt} = \lambda p_1(t) - \lambda p_2(t).
\]

Now constructing the system of moment equations
\[
\frac{dM_1(t)}{dt} = AM_1(t) + B \cdot 0,5\sqrt{\lambda} - \lambda M_1(t) + \lambda M_2(t),
\]
\[
\frac{dM_2(t)}{dt} = AM_2(t) - B \cdot 0,5\sqrt{\lambda} + \lambda M_1(t) - \lambda M_2(t), M_k(0) = 0 \quad k = 1,2.,
\]

From this system we find
\[
\frac{d(M_1(t) + M_2(t))}{dt} = A(M_1(t) + M_2(t)), M_1(t) + M_2(t) \equiv 0.
\]

For particular moments we have next system
\[
\frac{dD_1(t)}{dt} = AD_1(t) + D_1(t)A^* - \lambda D_1(t) + \lambda D_2(t) + AM_1(t)\sqrt{\lambda}B^* + B\sqrt{\lambda}M_1(t)A^* + 0,5BB^*,
\]
\[
\frac{dD_2(t)}{dt} = AD_2(t) + D_2(t)A^* + \lambda D_2(t) - \lambda D_2(t) + AM_2(t)\sqrt{\lambda}B^* + B\sqrt{\lambda}M_2(t)A^* + 0,5BB^*, D_k(0) = 0.
\]

\[ D(t) = \langle X(t)X^*(t) \rangle = D_1(t) + D_2(t) \]

We obtain matrix equation (2)

2 algorithm. From formula Ito [6]
\[ X(t + dt) = X(t) + dX(t) + \frac{1}{2}d^2X(t)+... = X(t) + (AX(t)dt + Bdw(t)) + \]
\[ + \frac{1}{2}(A(AX(t))dt + Bdw(t))dt+... = X(t) + AX(t)dt + Bdw(t) + O((dt)^{3/2}). \]

\[ X(t + dt) = X^*(t + dt) = X(t)X^*(t) + AX(t)X^*(t)dt \]
\[ + X(t)X^*(t)A^*dt + X(t)B^*dw(t) = BX^*(t)dw(t) + BB^*(dw(t))^2 + \]
\[ + O((dt)^{3/2}) = AD(t)dt + D(t)A^*dt + BB^*dt + O(dt). \]

If \( dt \to 0 \) obtain (2).

Rewrite system (1) in form
\[
\frac{dX(t)}{dt} = AX(t) + Bv(t),
\]

\( v(t) \) — white noise. If \( Re \lambda_j(A) < 0 \) we find solution
\[ X(t) = \int_0^\infty e^{A(t-\tau)} Bv(\tau)d\tau. \]

And for matrix second order we have:
\[
D(t) = \langle X(t)X^*(t) \rangle = \left[ \int_0^t e^{A(t-\tau)} Bv(\tau)d\tau \times \int_0^t B^*e^{A^*(t-s)} v(s)ds \right]
\]
\[
= \int_0^t e^{4(t-\tau)} BB^*d\tau \int_0^t e^{A^*(t-s)} \delta(\tau - s)ds = \]
\[
= \int_0^t e^{A(t-\tau)} BB^* e^{A^*(t-\tau)} d\tau = \int_0^t e^{At} BB^* e^{A^*t} d\tau.
\]

Then true (3). If \( \lim_{t \to +\infty} e^{At} = 0 \), then from equations (2) we have the value of matrix \( D(t) \) at \( t \to +\infty \).

**Theorem 2.** Для систем нелинейных дифференциальных стохастических уравнений

\[
\frac{dX(t)}{dt} = \Psi(t, X(t)) + \Phi(t, X(t))v(t),
\]

(4)

where \( v(t) \) — white noise the system of moment equations has kind

\[
\frac{dM(t)}{dt} = \int_{E_M} \Psi(t, y)f(t, y, h)dy,
\]

\[
\frac{dD(t)}{dt} = \int_{E_M} \left( \Psi(t, y)\gamma^* + \gamma\Psi^*(t, y) + \Phi(t, y)\Phi^*(t, y) \right)f(t, y, h)dy.
\]

(5)

**Proof.** System (4) we rewrite in kind [1]

\[
dX(t) = \Psi(t, X(t))dt + \Phi(t, X(t))dw(t),
\]

At first we prove that the system

\[
X_{k+1} = X_k + h\Psi(t_k, X_k) + \xi_k \sqrt{h}\Phi(t_k, X_k), t_k = kh, \quad (k = 0, 1, 2, \ldots)
\]

(8)

Defined difference approximation for the system equating (4), the \( \xi_k \) — have value

\( \pm 1 \) with probability \( p_1 = p_2 = \frac{1}{2} \).

\[
x = T(t, y, \sqrt{h}), T(t, y, \sqrt{h}) \equiv y + \sqrt{h}\Phi(t, y) + h\Psi(t, y)
\]

(9)

If \( h > 0 \) expression (7) has inverse transformation

\[
y = S(t, x, \sqrt{h}),
\]

(10)

\[
S(t, x, \sqrt{h}) = x - \sqrt{h}\Phi(t, x) - h\Psi(t, x) + h^\frac{\Phi(t, x)}{dx} \Phi(t, x) + O\left(h^{3/2} \right).
\]

If \( h = 0 \) Jacobian of transformation (9), (10) not equals 0 at all \( Y \) i \( X \), therefore

\[
\det \frac{DT(t, y, \sqrt{h})}{dy} \neq 0, \det \frac{DS(t, x, \sqrt{h})}{dx} \neq 0
\]

\[
\lim_{||y|| \to \infty} ||T(t, y, \sqrt{h})|| = \infty, \lim_{||x|| \to \infty} ||S(t, x, \sqrt{h})|| = \infty.
\]

Let \( f(t, x, h) \) - density of \( X_k \). The system equations (4) defined the solutions \( f(t, x, h) \)

\[
f(t + h, x, h) = \frac{1}{2} f(t, S(t, x, \sqrt{h}), h) \cdot \left| \det \frac{ds(t, x, \sqrt{h})}{dx} \right| +
\]

\[
+ \frac{1}{2} f(t, S(t, x, -\sqrt{h}), h) \cdot \left| \det \frac{ds(t, x, -\sqrt{h})}{dx} \right|.
\]

\[
f(t, x - \sqrt{h}\Phi(t, x) - h\Psi(t, x) + h^\frac{\Phi(t, x)}{dx} \Phi(t, x) + O\left(h^{3/2} \right), h) =
\]

\[
f(t, x, h) + \frac{df(t, x, h)}{dx} (-\sqrt{h}\Phi(t, x) - h\Psi(t, x) +
\]

\[
+ \frac{d\Phi(t, x)}{dx} \Phi(t, x) + \frac{1}{2} h\Phi^*(t, x) \frac{d}{dx} \left( \frac{df(t, x, h)}{dx} \right)^* \Phi(t, x) + O\left(h^{3/2} \right).
\]
And
\[
\det \frac{DS(t,x,\sqrt{h})}{dx} = \det \left( E - \sqrt{h} \frac{D\Phi(t,x)}{dx} - h \frac{D\Psi(t,x)}{dx} \right) + \\
+ h \frac{D}{dx} \left( \frac{D\Phi(t,x)}{dx} \Phi(t,x) \right) + O \left( h^{3/2} \right) = \det \left( E - \sqrt{h} \frac{D\Phi(t,x)}{dx} \right) \times \\
\times \det \left( E - h \frac{D\Psi(t,x)}{dx} \right) \det \left( E + h \frac{D}{dx} \left( \frac{D\Phi(t,x)}{dx} \Phi(t,x) \right) + O \left( h^{3/2} \right) \right).
\]
Calculating determinants value
\[
\det \left( E - h \frac{D\Psi(t,x)}{dx} \right) = 1 - h Sp \frac{D\Psi(t,x)}{dx} + O \left( h^2 \right) = \\
= 1 - h div\Psi(t,x) + O \left( h^2 \right);
\]
\[
\det \left( E + h \frac{D}{dx} \left( \frac{D\Phi(t,x)}{dx} \Phi(t,x) \right) \right) = 1 + h Sp \frac{D}{dx} \left( \frac{D\Phi(t,x)}{dx} \right) \Phi(t,x) + O \left( h^2 \right).
\]
If
\[
det \left( E - \sqrt{h} \frac{D\Phi(t,x)}{dx} \right) = 1 - \alpha \sqrt{h} + \beta h + O \left( h^{3/2} \right).
\]
then
\[
det \left( E + \sqrt{h} \frac{D\Phi(t,x)}{dx} \right) = 1 + \alpha \sqrt{h} + h \beta + O \left( h^{3/2} \right),
\]
where
\[
\alpha = Sp \frac{D\Phi(t,x)}{dx},
\]
\[
\beta = \frac{1}{2} \left( Sp \left( \frac{D\Phi(t,x)}{dx} \right)^2 - \frac{1}{2} Sp \left( \frac{D\Phi(t,x)}{dx} \right)^2 \right).
\]
\[
\det \left( E - \sqrt{h} \frac{D\Phi(t,x)}{dx} \right) \left( E + \sqrt{h} \frac{D\Phi(t,x)}{dx} \right) = 1 + h (2\beta - \alpha^2) + O \left( h^2 \right).
\]
\[
det \left( E - \sqrt{h} \frac{D\Phi(t,x)}{dx} \cdot \frac{D\Phi(t,x)}{dx} \right) = 1 - h Sp \left( \frac{D\Phi(t,x)}{dx} \cdot \frac{D\Phi(t,x)}{dx} \right) + O \left( h^2 \right) = \\
= 1 + h (2\beta - \alpha^2) + O \left( h^2 \right).
\]
and
\[
\det \frac{DS(t,x,\sqrt{h})}{dx} = 1 - \sqrt{h} div \Phi(t,x) - h div \Psi(t,x) + \\
+ \frac{h}{2} \left( div \Phi(t,x) \right)^2 + \frac{h}{2} \sum_{k,s=1}^m \left( \frac{\partial \phi_k(t,x)}{dx_s} \frac{\partial \phi_s(t,x)}{dx_k} \right) + \\
\frac{\partial \phi_s(t,x)}{dx_k} \phi_k(t,x) + O \left( h^{3/2} \right).
\]
where \( \phi_k(t,x)(k = 1, \ldots, m) \)—coordinate of vector \( \Phi(t,x) \).
\[
f(t, x) = -lim_{h \to 0} f(t, x, h).
\]
This equation coincides with FPK.
\[
\frac{\partial f(t,x)}{\partial t} = -\sum_{k=1}^{m} \frac{\partial f(t,x)\phi_k(t,x)}{\partial x_k} + \frac{1}{2} \sum_{k,s=1}^{m} \frac{\partial^2}{\partial x_k \partial x_s} \left( \phi_k(t,x) \phi_s(t,x) f(t,x) \right).
\]

In general case

\[
\frac{\partial f(t,x)}{\partial t} = -\sum_{k=1}^{m} \frac{\partial}{\partial x_k} \left( a_k(t,x) f(t,x) \right) + \frac{1}{2} \sum_{k,s=1}^{m} \frac{\partial^2}{\partial x_k \partial x_s} \left( b_{ks}(t,x) f(t,x) \right),
\]

\[a_k(t,x)(k = 1, \ldots, m), \ b_{ks}(t,x)(k, s = 1, \ldots, m)\]

Find from formula

\[a_k(t,x) = \lim_{h \to 0}^{-1}(x_k(t+h) - x_k(t)|X(t) = x),\]

\[b_{ks}(t,x) = \lim_{h \to 0}^{-1}(x_k(t+h) - x_k(t))(x_s(t+h) - x_s(t)|X(t) = x)(k, s = 1, \ldots, m).\]

From system equation (6) we find

\[a_k(t,x) = \lim_{h \to 0}^{-1}(s_k \sqrt{h}\phi_k(t,x) + h\phi_k(t,x)) = \phi_k(t,x),\]

\[b_{ks}(t,x) = \lim_{h \to 0}^{-1}(\xi_k \sqrt{h}\phi_k(t,x) + \xi \sqrt{h}\phi_s(t,x)) = \phi_k(t,x)\phi_s(t,x).\]

We proved first part. And now we will find moment equations.

From (9) find

\[\int_{E_m} yy^* f(t+h,y,h) dy = \frac{1}{2} \int_{E_m} T(t,y,\sqrt{h}) T^*(t,y,h) dy + \frac{1}{2} \int_{E_m} T(t,y,-\sqrt{h}) T^*(t,y,h) dy,\]

or

\[D(t+h) = \frac{1}{2} \int_{E_m} \left( \left( y + h \Psi(t,y) + \sqrt{h}\Phi(t,y) \left( y^* + h\Psi^*(t,y) + \sqrt{h}\Phi^*(t,y) \right) \right) \right) + \]

\[+ \left( y + h \Psi(t,y) - \sqrt{h}\Phi(t,y) \right) (y^* + h\Psi^*(t,y) - \sqrt{h}\Phi^*(t,y)) f(t,y,h) dy.\]

Then

\[D(t+h) = \int_{E_m} (yy^* + h\Psi^*(t,y) + h\Psi(t,y)yy^* + h\Phi(t,y)\Phi^*(t,y) + h^2 \Psi(t,y)\Psi^*(t,y)) f(t,y,h) dy.\]

and \[\int_{E_m} yy^* f(t,y,h) dy = D(t), \text{then } h \to 0 \text{ we have equations (5).} \]

**Lemma 1.** For the system equation

\[dX(t) = AXdt + BXdw(t)\]

The system (5) transformed to system

\[\frac{dD(t)}{dt} = AD(t) + D(t)A^* + BD(t)B^*.\]

**Lemma 2.** For the system equation

\[dX(t) = AX(t) + BdW(t), \text{dim } X(t) = m, \text{dim } W(t) = p,\]

\[\langle dW(t), dW^*(t) \rangle = Rdt, \text{dim } R = p \times p.\]

The system of moment equation has form

\[\frac{dD(t)}{dt} = AD(t) + D(t)A^* + BRB^*.\]

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If Re $\lambda_j(A) < 0$ ($j = 1, \ldots, m$), to
\[ D = \lim_{t \to \infty} e^{At} BRB^* e^{A^*t} dt \]

**Theorem 3.** For the system equation
\[ dX(t) = AX(t)dt + BX(t)dw(t), \]
Matrix equation $D(t) = \langle X(t)X^*(t) \rangle$ have next form
\[ \frac{dD(t)}{dt} = AD(t) + D(t)A^* + \frac{1}{2} BBD(t) + BD(t)B^* + \frac{1}{2} D(t)B'B'. \]

**Proof. 1 algorithm.** Now constructing next equations
\[
X(t + dt) = X(t) + dX(t) + \frac{1}{2} d^2 X(t) + \ldots = \\
X(t) + \left( AX(t)dt + BX(t)dw(t) \right) \\
+ \frac{1}{2} \left( A(AX(t)dt + BX(t)dw(t))dt + B(AX(t)dt + BX(t)dw(t))dw(t) \right) + \ldots = \\
X(t) + AX(t)dt + BX(t)dw(t) + \frac{1}{2} BBX(t)(dw(t))^2 + 0 ((\Delta t)^{3/2}).
\]
Then
\[
\langle X(t + dt)X^*(t + dt) = \langle X(t)X^*(t) + AX(t)X^*(t)dt + \\
X(t)X^2(t)A^*dt + BX(t)X^*(t)B^*(dw(t))^2 + \frac{1}{2} BBX(t)X^*(t)(dw(t1))^2 + \\
+ \frac{1}{2} X(t)X^*(t)B^*B^*(dw(t))^2 + 0(dt) \rangle.
\]
And we have matrix $D(t)$.

2 algorithm. Considering auxiliary system of equation
\[ \frac{dX(t)}{dt} = AX(t) + BX(t)\xi_2(t), \]
Where $\xi_2(t)$ — Markov process, which has value $\pm \sqrt{\lambda}$ with probability
\[ p_1(t) = P(\omega: \xi(t) = \sqrt{\lambda}), p_2(t) = P(\omega: \xi(t) = -\sqrt{\lambda}), \]
And its probability satisfied the system equation
\[ \frac{dp_1(t)}{dt} = -\lambda p_1(t) + \lambda p_2(t), \frac{dp_2(t)}{dt} = \lambda p_1(t) - \lambda p_2(t). \]
At $\lambda \to +\infty$ random process $\xi(t)$ touch to Winer process. For particular moments second order
$D_1(t), D_2(t)$ we obtain the next system of differential equations
\[
\frac{dD_1}{dt} = (A + B\sqrt{\lambda})D_1 + D_1(A^* + B^*\sqrt{\lambda}) - \lambda D_1 + \lambda D_2, \\
\frac{dD_2}{dt} = (A - B\sqrt{\lambda})D_2 + D_2(A^* - B^*\sqrt{\lambda}) + \lambda D_1 - \lambda D_2, D_1(0) = D_2(0) = 0.
\]
After replace
\[ D(t) = D_1(t) + D_2(t), V(t) = D_1(t) - D_2(t) \]

obtain
\[
\frac{dD}{dt} = AD + DA^* + \sqrt{\lambda}BV + \sqrt{\lambda}VB^*,
\]
\[
\frac{dD}{dt} = AV + VA^* + \sqrt{\lambda}BD + \sqrt{\lambda}DB^* - 2\lambda V.
\]

Parameter \( \lambda \) touch to \( \pm \infty \), therefore we have
\[
V = \frac{1}{2\sqrt{\lambda}}(BD + DB^*) + O(\lambda^{-2}).
\]

And used \( V \), obtained at \( \lambda \to +\infty \) equations (4) for matrix \( D(t) \).

**Comments.** The formula (4) differs from the formula (1), although the same system of stochastic differential equations were considered. The fact is that different definitions for the \( dX(t) \) differential were actually used.

**Theorem 4.** For the system equation
\[
dX(t) = \Psi(t, X(t))dt + \Phi(t, X(t))dw(t),
\]

The system of moment equation has form
\[
\frac{dM(t)}{dt} = \left\{ \Psi(t, X(t)) + \frac{1}{2} \frac{\partial \Phi(t, X(t))}{\partial x} \cdot \Phi(t, X(t)) \right\},
\]
\[
\frac{dD(t)}{dt} = \left\{ X(t)\Psi^*(t, X(t)) + \Psi(t, X(t))X^*(t) + \Phi(t, X(t))\Phi^*(t, X(t)) + \right.
\]
\[
+ \frac{1}{2} X(t)\Phi^*(t, X(t)) \frac{D\Phi}{Dx} \left( \frac{t, X(t)}{2} + \frac{1}{2} \frac{D\Phi(t, X(t))}{Dx} \Phi(t, X(t))X^*(t) \right).\]

**Proof.** Introduce auxiliary system of differential equation
\[
\frac{d\xi(t)}{dt} = \Psi(t, X(t)) + \Phi(t, X(t))\xi(t, \lambda),
\]

where \( \xi(t, \lambda) \) — Markov process which has two values \( \pm \sqrt{\lambda} \)

with probability \( p_1(t) = P\{\xi(t) = \sqrt{\lambda}\}, p_2(t) = P\{\xi(t) = -\sqrt{\lambda}\} \).

Let’s this probability satisfied the system equation
\[
\frac{dp_1(t)}{dt} = -\lambda p_2(t) + \lambda p_2(t), \frac{dp_2(t)}{dt} = \lambda p_1(t) - \lambda p_2(t).
\]

If \( \lambda \to +\infty \) random process \( \xi(t, \lambda) \) touch to Winer process. Now found system of equation for \( f(t, x, \lambda) \) strong solution of system (18)

\[
\frac{\partial f_1(t, x, \lambda)}{\partial t} = -\text{div} \left( f_1(t, x, \lambda) \left( \Psi(t, x) + \sqrt{\lambda}\Phi(t, x)) \right) \right) - \lambda f_1(t, x, \lambda) + \lambda f_2(t, x, \lambda),
\]
\[
\frac{\partial f_2(t, x, \lambda)}{\partial t} = -\text{div} \left( f_2(t, x, \lambda) \left( \Psi(t, x) + \sqrt{\lambda}\Phi(t, x)) \right) \right) + \lambda f_1(t, x, \lambda) + \lambda f_2(t, x, \lambda).
\]

\[
f(t, x, \lambda) = f(t, x, \lambda) + f_2(t, x, \lambda), v(t, x, \lambda) = f_1(t, x, \lambda) - f_2(t, x, \lambda).
\]

For function \( f(t, x, \lambda), v(t, x, \lambda) \) we obtain
\[
\frac{\partial f(t, x, \lambda)}{\partial t} = -\text{div}(f(t, x, \lambda)\Psi(t, x)) - \sqrt{\lambda}\text{div}(v(t, x, \lambda)\Phi(t, x)).
\]
\[ \frac{\partial v(t, x, \lambda)}{\partial t} = -\text{div}\left(v(t, x, \lambda)\Phi(t, x)\right) - \sqrt{\lambda} \text{div}\left(f(t, x, \lambda)\Phi(t, x)\right) - 2\lambda v(t, x, \lambda). \]

From second equation we have
\[ v(t, x, \lambda) = \frac{1}{2} \text{div}\left(f(t, x, \lambda)\Phi(t, x)\right) + O(\lambda^{-1}). \]

at \( \lambda \to +\infty \)
\[ f(t, x) = \lim_{\lambda \to +\infty} f(t, x, \lambda), \quad \frac{\partial f(t, x)}{\partial t} = -\text{div}\left(f(t, x)\Phi(t, x)\right) + \frac{1}{2} \text{div}\left(\text{div}\left(f(t, x)\Phi(t, x)\right)\Phi(t, x)\right). \]

This is equation FPK.

We found the system of moment equation
\[ X(t + dt) = X(t) + dX(t) + \frac{1}{2} d^2 X(t) + \ldots = X(t) + \left(\Psi(t, X(t))dt + \Phi(t, X(t))dw(t)\right) + \]
\[ + \frac{1}{2} \left(\frac{\partial \Psi(t, X(t))}{\partial t} dt^2 + \frac{D\Psi(t, X(t))}{Dx} \left(\Psi(t, X(t))dt + \Phi(t, X(t))dw(t)\right)dt\right) + \]
\[ + \frac{1}{2} \left(\frac{\partial \Phi(t, X(t))}{\partial t} dt + \frac{D\Phi(t, X(t))}{Dx} \left(\Psi(t, X(t))dt + \Phi(t, X(t))dw(t)\right)\right) dw(t) = X(t) + \Psi(t, X(t))dt + \]
\[ + \Phi(t, X(t))dw(t) + \frac{1}{2} \times \frac{D\Phi(t, X(t))}{Dx} \Phi(t, X(t)) (dw(t))^2 + \ldots \]

We obtained \( \text{M}(t) = \langle X(t) \rangle \) and \( \text{D}(t) = \langle X(t)X^*(t) \rangle \)
\[ \frac{d\text{M}(t)}{dt} = \left(\Psi(t, X(t)) + \frac{1}{2} \frac{D\Phi(t, X(t))}{Dx} \Phi(t, X(t))\right). \]
\[ \frac{d\text{D}(t)}{dt} = \langle X(t)\Phi^*(t, X(t)) + \Psi(t, X(t))X^*(t) + \Phi(t, X(t)) \cdot \Phi^*(t, X(t)) + \]
\[ + \frac{1}{2} X(t)\Phi^*(t, X(t)) \frac{D\Phi^*(t, X(t))}{Dx} + \frac{1}{2} \frac{D\Phi(t, X(t))}{Dx} \Phi(t, X(t)) \cdot X^*(t) \rangle. \]

**DISCUSSION**

On the basis of this formula, numerous problems of the theory of automatic control are solved, the theory of filtration and observing is constructed. Using this formula, they look for optimal control, minimizing dispersion, and build a linear stochastic control theory.

**CONCLUSION**

The moment equations for practically important classes of stochastic equations are obtained. Usually of interest is the question of the behaviours of the matrix of the second moments. solutions of the systems in question, because many optimization problems are reduced to minimization of such a matrix solutions of the systems in question, because many optimization problems are reduced to minimization of such a matrix.
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EFFECTIVE MANAGEMENT AND SUCCESS OF BUSINESS ETHICAL RELATIONSHIPS

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ABSTRACT

The ultimate goal of human activity is to become successful and important person in one’s chosen field. It is impossible to do so without realizing that you are a strong person, strong enough to influence others. However, human will is not just limited to dominating others; it can also cultivate harmonious relationships and coordination in ways that exclude jealousy, mistrust, envy, and disagreement between “Me” and “others”. It’s in this context that the issue of a proper relationship between a leader and employees is reviewed. Large companies value proper behavioral culture and provide guidelines that the management and higher ranking personnel must take into account. There are norms of behavior not only for employees, but also for leaders.

Objectives: Investigating attitudes of leaders and employees.

Methods/Approach: Scientific analysis methods such as deduction, analysis and synthesis, analyzing graphic data, dynamic research, forecasting, and others.

Results: As a result of the main analysis of the study the ethical issues surrounding business relationship. Opportunism as a business issue is addressed in economics and marketing literature as an important factor in transaction cost analysis and market governance. Management and business ethics scholars, however, do not address this issue in depth.

Conclusions: The Company needs a good market reputation, which first and foremost depends on its leadership.

Keywords: ethic, business, success, management, psychology, environment

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INTRODUCTION

The last decade has been a significant increase in business ethics research and literature. Investigating the deterrents of ethical behaviour is important as is increases understanding of the factors associated with business ethics and ethical decision-making also comprise useful areas for business ethics research. In particular, there is a need to study organizational outcomes of business ethics. At a corporate level, much can
be gained from understanding the association, if any, between a firm’s ethical behavior and its performance. (E.g. financial performance) (Appelbaum, 2005). On an individual level, consequences such as job satisfaction, stress, motivation, commitment, or job performance can have significant impact on organizations. Although, this area of business ethics research is potentially useful, little has been done to date. Traditionally, research in business ethics typically involves inquiry into the nature and ground and moral judgments, and standards and rules of conduct in situations involving business decisions (Murphy, 2007). Ethics is different from efficiency but the two are interdependent. Having an ethical sense pushes one to be responsible and to act in the best way for the purposes of efficiency (Bandzeladze, 2011). In turn, efficiency in a business firm is a contribution to the common good. An efficient use of means provides material support to human life and better accessibility to economic goods. Through increasing competitiveness, efficiency also contributes to maintaining jobs, so providing the livelihood of many people.

**METHODOLOGY**

Descriptive and analytical research design is followed in the study. We conducted the study on the available information that was published on the social pages of the certain websites and libraries. The article describes the current situation of the business ethics and effective management at companies.

**RESULTS AND DISCUSSION**

**Relevance of the subject**

Human will is not just limited to dominating others; it can also cultivate harmonious relationships and coordination in ways that exclude jealousy, mistrust, envy, and disagreement between "Me" and "others". It's in this context that the issue of a proper relationship between a leader and employees is reviewed. A leader may use various ways of engaging people (Deshpande, 1996). There are leaders who use their position for dominance, physical or psychological. There are leaders who build relationships with employees based on confidence (Neimanis, 1997). The methods used by them will also be different: the first uses punishment that is not particularly effective, the second uses a form of incentivization. For good leadership, education is necessary, although knowledge alone is insufficient; it is important to use the accumulated knowledge properly (Kohlberg, 1984). An educated person in a proper relationship to another person is able to direct his or her actions without violating the interests of others.

Any person thinks that life is given to us for success and happiness. A wise person is trying to understand his or her potential and then try to achieve it. On the way to achieving it, it is important for a person to believe in himself. Then the right action is inevitable.

In Japan, it is widely believed that the cornerstone of success is the right relationship with another person. Psychologists advise that the key to the way to success is belief in one's own strength. Simply setting the primary goal based on an idea and then taking action will not bring the desired results. The road is not easy and people have to overcome certain obstacles (Simpson, 2017). On must take into account and be guided by
the principle of respecting the interests of another person, should put aside hatred, envy, suspicion, attitude, irony (Williams, 1985). All of these factors are impediments on the way to success.

In any activity it is desirable to lead by the following principle: treat people the way you want to be treated. Or never do to other people what you don't want to be done to yourself. That is, on the way to success, it is important to have a relationship with another person. This is an art in itself. Self-control and self-awareness are also important factors in this regard (Fritzche, D. J. and H. Becker, 1984). Making the right choice is an exhilarating risk. The right choice is only half the battle, however; the driving intention and psychological understanding accompany every successful step, creating desire for new success. The result is the perfection and growth of personal qualities.

Among the basics of success, communication is the most important. Today, it is often claimed that success is conditioned not by professionalism, but by human relationships.

If a person wants to leave a good impression on another and make him a loyal partner, it is important to use the following methods in relationships:

1. People are magnetized by mention of their names. It causes favor and pleasant emotions in them. When mentioning someone's name, we emphasize this person's personality. Most people have a desire to be perceived not only as a human being, but also as a person. The person's mood changes and seeks to get closer to those who cause positive emotions in this regard. It is desirable to remember the name of the people you often have to communicate with.

2. Smile - If you want to gain someone's positive disposition, smiling at them is a surefire way. It is an indispensable means of forming bonds. Faking a smile is hard. Keep in mind that the more often you smile at people, the more you will win their favor and achieve success.

3. Compliment - a sincere, proper compliment is the shortest way to a human heart. The more often a person hears "you deserve more", the more he or she will do. A faked compliment is undesirable but still pleasant to listen to.

The aforementioned methods are used not only in everyday activities but also in business relationships.

One may wonder about the art of properly holding a business conversation, however. What is the optimal way? There are many answers to this question; below you may find some of them.

The main method of drawing more attention from the opposite side to create a smiling, pleasant, emotional environment. At the meeting, the conversation is started by the highest ranking representative of one of the sides with "The purpose of our question/meeting is...". Everyone meets this moment in silence and hears the introduction out.

The initiative of starting a business meeting belongs to the host side, but finishing it is the privilege of the guest side. If one of the party's suggestions are not acceptable, the situation should be relieved by a positive gesture or an appropriate question. It is inadmissible to express threatening or excessive emotion or use expressions such as "the only way", "I do not want", "necessary". It is best to use the following expressions instead: "Maybe we should try", "Wouldn't it be better" ...
The opposing sides are trying to convince each other in the advantage of their respective proposals. In this regard, human action is different: there are people who find a way out of any situation and manage to defend their opinion. Some lean on the authority of their rank during negotiations, some make the most of their ability to take some risk. There are those who manage combine their own interests with the opposing party's. What matters is that the agreement is made by individuals with a competent, professional, personal image.

The important part of the business conversation is to make the right decision in a timely manner. A protracted decision causes distrust. Efficiency is vital. Eventually everything is affirmed by a contract. Both parties are obliged to calculate the expected negative result, to avoid uncertainty. Sometimes, for a successful conclusion, small compromises are also desirable. The more intelligent and rational the compromise, the more desirable the result.

For proper conduct in any field, the style of governance is as important as interpersonal relationships. It affects not only the activity itself but also the fate of human beings involved. Proper styles of governance allow each employee a means of self-identification.

Large companies value proper behavioral culture and provide guidelines that the management and higher ranking personnel must take into account. There are norms of behavior not only for employees, but also for leaders.

Within the framework of the study, employees of medium and large companies were interviewed. The main question was «What should the management's etiquette be like?» The received feedback was as follows:

A leader’s etiquette must be aimed at:
1. Earning each employee's trust, regardless of rank;
2. Determining the share and contribution of each employee to the company's overall profits;
3. Integrity;
4. Discipline;
5. Acknowledging and incentivizing creative and innovative activity of certain employees.

Why does business succeed? A successful business owner requires more than a brilliant idea and hard work. You have to learn how to manage and develop your business. In this process you will find many challenges and the ability to satisfy them will be the main factor of your success (or failure) (D&B, 2008). In order to give your business a fighting chance, you have to do the following:

Knowing your job sounds obvious, but successful businessmen really understand what they are doing. They know about the industry in which they operate and know who their competitors are. They know how to attract customers, who are the best suppliers and distributors and understand the impact of technology on their business.
You need to know the basics of business management. You can start a business based on an excellent idea, but you need to understand the functional areas of business - accounting, finance, management, marketing and production. You have to be a salesman, a decision maker and a planner.

Have appropriate attitudes. If you are going to devote the time and energy to turn the idea into a successful job, you must have a passion for your job. You have to believe what you are doing and have a strong responsibility towards your business.

You need to get adequate funding. Business in its initial phase (which can last for more than a year) requires a lot of money. You may have the most brilliant idea in the world, the best marketing approach and a talented management team, but if you run out of money, your career as a business owner can be short-lived. Plan long-term and work with lenders and investors to make sure you have enough funds to open and expand.

You should be able to manage money efficiently. You will be under constant pressure to find money to pay salaries and taxes. Therefore, you should keep an eye on the movement of cash - inflow and outflow. You need to control the costs and accumulate money. In general, you need to know how to collect the financial information you need for your business to function.

Manage time effectively. The new business owner can work over sixty hours a week. If you want to develop a business, you will inevitably have to give up some control - allow others to do their share of. So you need to develop time management skills and learn to delegate responsibility. Proper timing is 48% of success. This includes demand for the business at the market and timely and operational implementation of appropriate financial operations.

You need to know how to manage people. Hiring, maintaining, and managing good people is crucial for success of your business. As it grows, you will also grow more dependent on your employees. You need to form a positive working relationship with them, properly train them, and motivate them to produce quality goods or services.

Keep your customers happy. You may attract them with impressive advertising campaigns, but you will retain them only by delivering quality goods or services.

You should be able to gain a competitive advantage. Find your niche in the market, keep an eye on your competitors, and get ready for changes in the market. History of business (and life in general) can be summarized in three words: "Adapt or die."

So why do businesses die?

If you pay attention to the operation of shopping centers for several years, you will notice that retailers come and go with an amazing frequency. The same thing happens with restaurants. Starting a business - small or large - is risky. A third of small businesses that have employees disappear within the first two years. More than half of small businesses closes within four years and 70 percent do not last to celebrate their seventh anniversary.

No matter how bad these business survival statistics look, some fields are worse than others. If you want to stay in business for a long time, it's wise to avoid some risky fields. And while your friends may think you
make the best pizza in the world, it does not mean you will succeed as a pizza joint owner. Opening a restaurant or bar is one of the most risky cases (and therefore difficult to get initial funding for). You can also rule out the transportation industry. Owning a taxi may seem profitable until you find out how much a taxi license costs. And while it may differ from city to city, in New York, for example, it exceeds $400,000. Creating a retail store may also prove quite difficult. A single bad sales season may spell the end for your business. The same goes for stores that sell communication devices: all shopping centers and malls have one or more mobile phone stores, so competition is tough and business can be very difficult (Pharell, 2011).

Businesses fail for many reasons, but many experts agree that the overwhelming majority of failures are the result of the combination of the following problems:

**Poor business idea.** Like any idea, a business idea can be flawed in both concept and performance. If you set up a snow factory on Hawaii, your competition might be minimal, but you would still be doomed to failure.

**Monetary problems.** Too many new businesses are underfunded. The owner borrows enough money to set up a business, but does not have enough extra cash to start the initial phase when very little money flows in, but a lot flows out.

**Managerial inexperience or incompetence.** Many new business owners have no business experience; many only have limited management skills. The owner may know how to make or sell the product, but he might not know how to manage. The owner may not be able to attract and retain talented employees. The owner may also have poor leadership abilities and fail to plan in advance.

**Non-customer-oriented approach.** The main advantage of a small business is the ability to pay special attention to consumers. But some small businesses fail to make use of this advantage. The owner may also fail to take into account the needs of the customer or to outdo the competitors who are doing the same.

**Failure to grow.** You think the sales growth will be good. Often this is the case, of course, but sometimes it can be a major problem. When the company grows, the role of the owner changes. He has to hand over the job to others and build a business structure that will handle the volume of growth. Some owners fail to make this transition

**CONCLUSION**

**The results of the study allow for the following conclusions:**

The company needs a good market reputation, which first and foremost depends on its leadership. The leader's etiquette begins with a greeting. He greets all employees, regardless of rank. The leader should feel comfortable at work, which means he must identify with the collective. At the same time, he must be an individual and should be respected for who he really is.

If the leader is guided by strictly defined rules of etiquette in his relations with staff and other company representatives, success is guaranteed, which is the ultimate goal.
The reputation of the leader and the company is inseparable. We tried to list the components that a good leader should have to ensure the success of the company. Discuss the importance of the work, and/or suggest possible applications and extensions of the further research.

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All authors have read and agreed to the published version of the manuscript.

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**Conflict of interests**
The authors declare no conflict of interest.

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ROLE OF PEDAGOGICAL INTERNESHIP FOR EDUCATIONAL TRANSFORMATION

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ABSTRACT
Pedagogical internship is the milestone for educational transformation of learners/internees. It is a core foundation for the all learners and teachers. Experiential learning uplifts the student into higher level of standard. It is a kind of breakthrough in studying social entrepreneurship education. Teacher and student both can learn how to make study better to improve quality education. The main aim of this investigation is to discern the importance of pedagogical internship for educational transformation. This scientific paper is based on scientific review of significance of pedagogical internship for educational transformation to the educational stakeholders. Pedagogical internship has a value to create the quality education and skill to learn. The pedagogical internship may furnish by learning transformational policy, competence, skills, educational network, collaborative teaching and learning, research, education and development with the effort of practical experiences. Thus, the implication of innovative pedagogical internship has greater meaning in short run and in long term by keeping continuous engagement of social enterprisers for solving social risk and uncertainties in business as well. Pedagogical internship has positive role. Pedagogical internship fosters creativity and innovation that depends on reading, reviewing and research. Every positive transformational possibilities in education is coming from pedagogical internship based information, communication, collaboration, innovative materials, research, knowledge building, experience sharing and ideas exchange from generation to generation individually and institutionally. Internship has attracted positive attitude, commitment, and professional behavior. Pedagogical internee finds collaborative and academic environment to be educated. It is reflective mode of teaching and learning to develop stakeholders as an intellect who can take part of quality teaching and learning. Therefore, students should not miss such an opportunity which can engage, approaches learning methods, expand learning skills and new perspectives. Provision of pedagogical internship has given effective communication and power of mentorship in systematic way.

Background
Objectives: The main objective of the study is to discover the function of pedagogical internship for educational transformation.

Methods/Approach: This scientific paper is based on scientific review of significance of pedagogical internship for educational transformation to the educational stakeholders.

Results: Every positive transformational possibilities in education is coming from pedagogical internship based information, communication, collaboration, innovative materials, research, knowledge building, experience sharing and ideas exchange from generation to generation individually and institutionally. Internship has attracted positive attitude, commitment, and professional behavior.

Conclusions: It is reflective mode of teaching and learning to develop stakeholders as an intellect who can take part of quality teaching and learning. Therefore, an individual should not neglect such an opportunity that engage, approaches learning methods expand learning skills, and develop new vision.

Keywords: Pedagogical Internship, Educational Innovation, Social Entrepreneurship, Research and Development.

JEL classification: I21, I23, O35

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INTRODUCTION

Pedagogical internship is the study and practice of innovative dynamic teaching learning methods for social entrepreneurship idea. Innovative internshipteaching learning methods are based on skill of knowledge exchange of social entrepreneurship. The fact that mentor is necessary for a student as a model, from whom he can get practical experience (Stankevičienė & Monkevičienė, 2007). It is learning and teaching both achievements during internship. While exchanging the knowledge, capacity of mentorship can be explored. Efficient mentorship is complex, because it comprises individual demand and teaching program, goal integration, accentuates relation, mentor pedagogical knowledge, personal quality, self-motivation and professional ability importance (Paulikienė, 2014). Mentorship is not easy task. It is more systematic.

Pedagogical internship is source of learning skill and dissemination skills of mentors. Research skill and presentation of knowledge has broad value in the society with great deal of understanding and teaching. Self-understanding and self-awareness are important so which clarifying values, reaction, cultures, thinking and communication (Baird, 2011). Internship can make possible of learning knowledge and thinking very effectively. Fil. Dr. Jan-U. Sandal Institute, Norway organized online internship, which was suitable for participants from Norway to Nepal. It is a modern pedagogy as favored by science and technological development. It is an academic activity in group and individual following case studies, team and individual assessments, problem identification and ways of solution presentation are the root of pedagogical internship. Vary innovative approach of learning is carried by the Fil. Dr. Jan-U. Sandal Institute, Norway.

METHODOLOGY

The Social Entrepreneur School IBS is an executive business education specialized on social entrepreneurship, innovation, management and service vision management in Fil. Dr. Jan-U. Sandal Institute, Norway promoting. This course has focused on clarification of concepts, production processes, innovation areas, development strategies, profits, and special motivators, traditional barriers to innovation, myths versus possibilities and perspectives as well as innovation and entrepreneurship in historical perspective.

RESULTS

Social entrepreneurship is an academic training, which is improving learning skill, and supporting to career. As the education given by Fil. Dr. Jan-U. Sandal Institute, everyone associated is achieving best learning approach in practical manner. This program offers knowledge of social entrepreneurship to different participants in the world by taking some practical activities. Its physical pedagogy can be participatory learning. After the spread of covid-19, teaching modality has become in online mode. The pedagogy has been changed paradigm shift towards distance mode with participatory via online training.

Students do experience on pedagogue profession, discovery and personal abilities. This depends on another researcher’s position along with potential to growth of profession by pedagogical internship from fresh into
well informed educator (Romm et al., 2010). Reading materials and analysis of study material exposes educator’s very efficient and effective presentation. This process increases the transformational capacities of mentors and contributes to teaching sectors.

Another build up is to make training in social entrepreneurship to have management training, program evaluation and other social works among the students and the community. This is to help social entrepreneurship activities and future professional career. Institution is required to prepare future social entrepreneurs to motivate all sectors. However, awareness between entrepreneurship and social entrepreneurship can achieve the goal of social value. Therefore, universities will produce humanistic values to graduates (Sundin, 2011). Starting internship is a kind of training in teaching field, which engage students' management of training, evaluation of students performance and work of team, which prepares them for future work management. These types of attention enable to be social entrepreneur. This type of internship is skill enhancer to the challenges of students and teachers both.

Teachers involve in teaching with students to develop the confidence, risk-taking behavior and professional growth (Forbes, 2004). During the internship period, teachers have catalyst role to build confidence in problem solving process and experiment all activities to build confidence, bear risk and growth. Teaching such group gives strength of teaching style.

Pedagogy requires in institutions teaching same discipline. Sharing knowledge among institution about teaching social entrepreneurship may use same pedagogy. A drop box is a tool to facilitate institution and educator for practice method (Fagerberg & Verspagen, 2009). Every institution need students and teachers group so that they follow the common pedagogical platform to exchange the ideas in one side and on the other side, and it is a place where teacher get an opportunity to tell about social entrepreneurship and method of practical activities.

Self-authorship, re-engagement, and commitment are the opportunities of intern that support to avoid challenges bringing opportunity by problem-solving skills (Sweitzer & King, 2014). In the internship, teacher has a way to be professional for teaching all aspects developing the behavior to be independent authorship, study engagement and kind of responsibility as a mentor.

Well-organized mentorship is composite. It comprises individual wants and teaching goal integration, accentuates relation, mentor pedagogical knowledge, personal quality, self-motivation and professional ability importance (Paulikienė, 2014). It builds teacher a very consistent, integrated, motivator and good relation maker. Besides teacher follows the best way of pedagogical teaching which is multitasking. It is a hard work to build professional career combining many aspects. Experiences are observed to examine learner’s intellectuality and morality. The larger community gets benefits from learning and experience create conditions leading to growth of future (Dewey, 1933). Learning behavior is a kind of having experiences through intellectual practices that helps to the students for their study and teacher creates an opportunity of learning environment. Education activates to facilitate in knowledge gain, learning and intellectual complexity.
Also, accelerate transformational experiences as per the associate with learning task (Swaner, 2012). To gain knowledge, pedagogical internship is best tool for teacher. Teacher transformed with skill and knowledge with deep understanding as to reforming complexities.

Visual attention is useful for visual awareness for the mechanism of anyone’s work (Konnikova, 2013). Pedagogical internship gives an attention of visual awareness of all practices of engagements. The program carries work mechanism that fulfills the need of study and teaching method. Education is an important for humanity, which determines a factor for development of mankind. Education can be a best dimension for overall development and activities of human capital. It makes mankind more dynamic and innovative. The process of training in teaching has a great effort for the human capital to be used in production process.

“A pedagogy of internship calls upon the academy, first and foremost, to recognize the internship as a legitimate, collaborative, academic learning experience requiring both structural support and the accountability of faculty, students, and partners. It demands of those involved in the learning triangle a conscious attentiveness to the process and goals of learning and the journey taken to reach those goals. Considerable weight falls upon the shoulders of the campus faculty and staff to ensure that systems are in place that foster deep learning, from selecting the site and supervisors to designing the Learning Contract, to embedding the experience in reflective ways of learning, to involving the student-intern actively throughout the process. Knowing how to use the domains of learning so that student interns have the tools they need to empower themselves in each of the dimensions of learning and development is essential; understanding the power of engaged learning and critical reflection in the learning process is crucial; and, understanding the requisite role of the faculty/staff working with student-interns and the powerful role of supervision is absolutely necessary” (King & Sweitzer, 2014.). Pedagogical internship is method of teacher developer program. Teacher could be goal oriented. Expression among students is realized to be experienced one. Both teacher and students are empowered simultaneously.

A very useful knowledge of social entrepreneurship, its mission, experiences of presenters, and internship are related more to the society rather than classroom. Students realize all idea of social entrepreneurship (De Villiers et. al., 2018). A classroom is a society to be learnt and to explore the skills in an individual development. All speakers involve in outside the class and inside the class boost up being educated with greater positive impact in society.

Experiential learning is a tool that has reflections of all ideas in learning. The main source is the journal (Bringle & Hatcher, 1999). Pedagogical internship is a common platform for learning knowledge and expanding knowledge as reflection of research. Reviews and previews are carried in teaching class so which comes with updated research journals’ findings. Entrepreneurship educators who engage students as co-learners and evoke their curiosity with new questions will create new ideas and support them in building confidence to develop alternate understanding of how entrepreneurship can benefit them and the society as a whole in the future. Such process is adopted through pedagogical process of invention, stimulating curiosity,
co-creation, thought provoking questions and entrepreneurial action (Verduijn & Berglund, 2019). In the pedagogical class, all participants know the area of questions to share their curiosity among them to derive new opinion as a new idea. The process of having confidence is a benefit for all. All activities adopted while teaching in an internship manage knowledge of entrepreneurship and social entrepreneurship in scientific way. Advance pedagogy helps to enhance the teaching and learning performance for which various innovative teaching methods are being used at the global level including the use of new technology (Khairnar, 2015). Teaching performance becomes effective measures to conduct pedagogical internship. Adopting a new technology is secured option for the teaching and learning. Its advancement through technology has uplifted measure breakthrough for teaching performance. It is necessary for each scientist or teacher to look for new knowledge and the latest pedagogical methods in order to keep up with the challenges of the digital economy and globalization.

Nowadays, the successful use by teachers of innovative ways of teaching various disciplines is a vital need for education. The author sees it possible to apply the acquired knowledge during the internship to transfer and even train practicing lawyers, tax consultants, accountants and specialists from several other professions. Higher education educators can also successfully use the innovative ice-breaking program of the Social Entrepreneur School IBS program to train students of various specialties, including lawyers, economists, and other types of specialization (Sereda, 2020). All teachers learn and share knowledge in updated version. It has affected by new changes of the society. As an author, it is an opportunity to be rationalized in managing and understanding the ideas and pedagogy. It has become milestone for teaching success and learning patterns.

There is need to apply social entrepreneurship in education and the focus is on the provision of teaching and giving more enlightenment about social impact to the society rather than focusing on profit as the end output. Hence, using social media platforms to gain the information and insight of people about this topic, gives an interesting product. The discussion about social entrepreneurship can be used to give more information to students by creating modules of the teaching and learning process. Besides, the validation process is a must to make sure that this topic is relevant to be taught in the university. It can also create awareness about social entrepreneurship, which have some slight difference in the end terms. A lot of students can have more interest in joining the activities that have been arranged by the university or other organizations. The idea of giving more to the society will encourage more activities that the students and universities can undergo. Also, the entirety of the social mission can be done to get more social impact (Muhammad Hamirul, Hamizan Roslan et. al., 2019,). Profit is not to be imagined in this activity. Social media platform is to be used to teach social entrepreneurship education. Class of social entrepreneurship is taught in university but social impact can be done via pedagogical internship incorporating many learning works. Provision of teaching has given effective communication and power of mentorship in systematic way.

“The pedagogical teaching approach in classroom environment for learning social entrepreneurship is something that one can consider as one of the best methods of teaching. It helps to explore and learn emerging
social entrepreneurship at the global level that can teach individuals to adopt innovative methods so they can achieve goals based on their objectives for better learning outcomes. This gradually strives in boosting social entrepreneurship for better living. The Professor and students’ interactive learning approach in the classroom is combined of presentation, group works, case studies, mockups, project and problem solutions based teaching, individual supervisions as well as group supervision is something that students, around the world, can learn effectively for expected learning outcomes. It all focuses in boosting social entrepreneurship for shared prosperity and entrepreneurial advancement with innovative approach” (Tiwari, 2020).

It is an environment of classroom as an excellent way of teaching. The development of social entrepreneurship is learnt. The learning behavior has been changed with a very progressive way. Interactive class, presentation, group works, case studies, mockups, project and problem solutions based teaching, individual supervisions as well as group supervision are the practices making classroom oriented pedagogical teaching approach very focused and enlightened knowledge of social entrepreneurship.

“Starting in the fall of 2020, Social Entrepreneur School IBS “transitioned” from the classroom to online. Today, the academic semester is characterized by peculiarities compared to the previous ones, as training during it was carried out using online tools, which provided for the existence of certain difficulties associated with communication with students, but also allowed the continuation of the practice of The Social Entrepreneur School IBS for students all over the world. Due to the peculiarities of teaching the discipline, the existence of which is associated with the distance form used in 2020, the basic methods have been slightly modified and diversified to intensify the involvement of students in the process. Thus, in the course of the lectures, a step-by-step discussion with the listeners of each of the proposed illustrative slides was used. In addition, students were invited to provide examples from their own experiences. In addition, before the lecture, students were asked to take notes on at least two questions related to the topic that they could ask anyone present at the end of the lecture” (Tkachuk, 2021).

By many causes; teaching pedagogy may not be in physical mode, so that online it happens. Using online tools teaching becomes more effective. It becomes a typically exciting program for teachers and learners to learn idea of teaching learning activities. Discussion, illustration, question, and answer session develop teacher very sound in teaching and getting new experiences. In overall, reflection could be such as presented in figure one, which teacher and students fulfilled.

The effort of professor is really motivational and inspirational in this world. The two-week program is more transformational for Affiliated Honorary Research Fellow of the Fil. Dr. Jan-U. Sandal Institute, Norway, 2021. Session of Professor Fil. Dr. Jan-Urban Sandal during internship period reflected as an irreplaceable. Interest of independent researchers and inspiration of learning of science both have virtue of skilling to all participants. The figure one demonstrates adaptation of teaching and learning techniques from which participants reflects by exchange of ideas and presentation by having understanding of knowledge of innovation and research knowing quality knowledge of social entrepreneurship education.
"Dynamic pedagogy does not take place within the knowledge and education industry, which is characterized by static and non-innovative learning methods. The knowledge industry transmits established truths and dogmas, and very often propaganda and political and religious lies to students. The knowledge industry is a part of the labor and commercial markets and functions as vocation school, both at lower and higher levels, like f. ex. university level within the Bologna process. Both teachers and students depend on wages and economic benefits, which are state or privately funded. The production costs are paid for by state or private, even though fees at rather high rates are common at prestigious universities and colleges. The knowledge industry functions like profit centers. The pedagogical principles are based on repetition and control and the goal of the knowledge industry is to provide future employers to the labor market. Most of the subject taught at universities are market oriented, and that makes the system suffer from lag and insufficiency, because no one can predict the future demand of labor in an open market“ (Sandal, 2012). Education sector is contributed by teachers and students engagement. This type of industry is developed by pedagogical internship. All have laborious efforts to generate innovative idea from which all graduates are skilled and become goal oriented. Teachers are developed gradually in the education industry as an employers and employees. As an effective and dynamics source, educated laboris contributing this industry by having exposure of many more via pedagogical internship.

The learners were grateful to professor in learning teaching pedagogy. It was highly impressive and innovative. Interpretation of content is great knowledge, which is useful in every context of business,
entrepreneurship development and social growth. Creativity and innovation depends on reading, reviewing and research. The quality of following all instruction is great part to be transformed for an individual. By these independent learners are growing with advance knowledge of social entrepreneurship.

DISCUSSION

A very sound example of such application and transformations is the “Social Entrepreneur School IBS” of Fil. Dr. Jan-U. Sandal Institute. It is a unique example of an educational and intellectual establishment that has given theoretical and practical learning behaviors for social entrepreneurs, educationist, practitioner and the learners all over the world. It is a great responsibility as key social responsibility to sustainability of business. According to the official site of the Fil. Dr. Jan-U. Sandal Institute, the Social Entrepreneur School IBS is an Executive Business Education specialized in Social Entrepreneurship (SE), Innovation Management (IM) and Service Vision Management (SV). The Social Entrepreneur School IBS is a 20 weeks long full-time program casing three separate courses − International Study Course in Social Entrepreneurship; − International Study Course in Innovation Management; − International Study Course in Service Vision Management. Each training course is accessible on the website of Fil. Dr. Jan-U. Sandal Institute. Due to the covid-19 pandemic, pedagogical internship was held via online. High-level technical zoom social entrepreneurship training was conducted from Fil. Dr. Jan-U. Sandal Institute. The online internship was part of accomplishment of study of learning by doing.

This pedagogical internship led teaching techniques holds components of the courses includes not only a lecture series but also individual assessment, case study, and question and answer. The final exam consists of the completion of a written task; oral exam and preparation and viva performed in group’s fellow students. The course has empowered students with soft skill and practical knowledge. Everyone can learn more from the course and internship because this program is part of effective teaching and learning. Knowledge specification with social entrepreneurship is a best part of internship. Everyone have been enlightened and transformed as per the effort.

Modern pedagogical science is in the process of constant development. In the theory and practice of pedagogy, there are a large number of different concepts, theories, and approaches to learning, based on certain educational goals, on certain features of the transfer or acquisition of knowledge, the development of students' personalities. Learning technologies are characterized by rational organization of educational activities, the ability to obtain the desired result at the lowest cost, the introduction of systematic thinking, which allows you to make the learning process manageable, the orderliness of actions that ensure the achievement of pedagogical goals (Pavlenko, 2014). Both theories and practices involved in modern internship system. Different personalities are producing. Many professional behaviors are reflected during the teaching learning activities. Many learning activities are carried out. Process of thinking is elaborated. In the internship, teaching and learning process is manageable.
Both physical and online internship is perfect platform to the teacher as well. Unlike, it was process from which the pedagogy led from class coach to online. It was impactful to provide Social Entrepreneur School IBS education as means to be transformed. This teaching media had faced the problem of communication to each other however; the practice of learning had not been stopped. It was a kind of distance learning too. And as an initial learning everyone learn from lecture, discussion, illustration of slides, opinion exchange, idea sharing, own experience sharing, taking key notes, presenting key notes, questions and answer model were adopted in the online training because of great understanding of lesions, pedagogical internship and quality of social entrepreneurship education. This schooling has great influence to the learner’s research fellows as effective online platform for learning pedagogy and internship amid pandemic. As per the requirements of learning knowledge and skills, innovative method is pedagogical internship adaptation, understanding, research, review and deep learning.

As a role of assistant professor, one can get great opportunity to learn practice of innovative dynamic learning methods going through the thematic presentation including experience and knowledge of Professor Fil. Dr. Jan-Urban Sandal and mine. It is great practice in case of learning knowledge of social entrepreneurship and having understanding in innovative learning methods as well as administrative role as a assistant professor as a mandatory part of the Affiliated Honorary Research Fellow Program fulfilling requirement of graduation from the Social Entrepreneur School IBS, and the scientific courses What is science, VP-01-A and Reading Course, RC-01-A. In this way, it is modern learning technique for fellows of Fil. Dr. Jan-U. Sandal Institute. The pedagogy learning was followed with instrumental scientific method of focusing on nurture of research fellows, socialization, knowledge advancement, course motivation, group learning and groups work. Stimuli factor of pedagogy has a great role because that influence the everything in skill development. This enforce the perception of reality. All exposure and information available is contemporary knowledgeable discussion with philosophy and discussion. This type of teaching is an advantage for all professional and researchers.

It seems that social entrepreneur pedagogical internship is not just an academic training module for multidisciplinary subject researchers and learners. It is rather a special curriculum and improving the existing professional careers. It depends how research fellows or students can adapt this learning approach, which has been developed by Fil. Dr. Jan-U. Sandal Institute through scientific and innovative teaching method for the betterment from transition to transformation. A learners gain many more opportunity from engagement of pedagogical internship.

**Personally learned from internship practicing as assistant professor**

By the pedagogical internship, as a teacher at first, I have gained knowledge of entrepreneurship and social entrepreneurship awareness, teaching skills of entrepreneurship and social entrepreneurship knowledge, preparation for teaching, material management in teaching effective deliberation of entrepreneurship and social
entrepreneurship, activating learners in learning entrepreneurship and social entrepreneurship, learning qualities of narrating examples of social entrepreneurship development. Similarly, I build up the confidence in public speaking, discussion, questioning and answering, handling teaching tools, way of opinion exchange, and communication of entrepreneurship, social entrepreneurship, innovation, research and social development. It has built up my personalities and professional behaviors. It has strengthened my skill of presentation, handling group works, creating case studies, style of mockups, project and assignment based teaching, individual supervisions as well as group supervision in teaching.

I gained knowledge with clarification of concepts of Social Entrepreneurship (SE), production processes, innovation areas, development strategies, profits, special motivators, traditional barriers to innovation, myths versus possibilities and perspectives. Innovation and entrepreneurship in historical perspective as mentored by Professor Fil. Dr. Jan-Urban Sandal.

Pedagogical learning methods were facilitated and instructed me by lectures of Professor Fil. Dr. Jan-Urban Sandal and his conversations with participants, group work, individual work assignment and result. Especially, for me, such tools were highly effective acknowledging both theory and practice of SE, IM, and SV via online platform. As a very effective learning method; specifically, I learnt how to follow pedagogical learning method while presenting theme and scientific study as well as effective teaching.

It was my unique experience that my main responsibility was to present independent theme lectures by which I got knowledge of SE, IM & SV in depth form. I had assisted pedagogical and administrative work too. I followed practice of innovative learning methods like theme presentation, interaction, Q & A group and individual performance with participants that was enabled me to understand deeply about knowledge of SE and economic development, SE, IM and consumer behavior in SV as an advance knowledge.

I have been teaching and learning experience such as how to conduct training, how to read how to conduct research, how to write, how to present, how to communicate and how to help understand about idea of social entrepreneurship as well as gaining knowledge of innovation management and service vision management and its approaches to other branch of knowledge. In addition, I have increased skill of qualitative research on social entrepreneurship field.

Similarly, participating in the summits; I develop skill of the keynote speaker as presenter. I learnt to participate in the Summit of social entrepreneurship. While writing scientific article, I am exploring skills as an international independent scientist. Besides, I am acknowledging the knowledge of how to write research articles and publishing criteria. Moreover, I got an opportunity to meet intellectual persons via physical and online conference and young social entrepreneurship learners from different countries who have high exposures in multidisciplinary subjects with relation to social entrepreneurship.
CONCLUSIONS

In conclusions, the Social Entrepreneur School IBS has been opening the idea and perspectives in the context of changing social business issues. Innovation and its impact seems high positive in the world’s interests. This has made us a very enthusiast boosting skills to understand the knowledge of entrepreneurship history, nature of social entrepreneurship, innovation, creativity, business philosophy, democracy, political context, market, consumer behavior and many more.

Pedagogical internship is platform for internship experience to gain skills knowledge and value in the society as teacher. This learning pedagogy has broadened the practices of broad learning and teaching opportunity in science. This institute pedagogy strengthens an understanding of some learning technique such as analysis, problem solving, teamwork, and social responsibility, and incorporates them with professional career and teaching learning habits. Internship has attracted attitude, commitment and professional behavior. In the social entrepreneurship discipline, theories and philosophical aspect are key to engage in the study. Pedagogical participants find collaborative and academic environment. It is reflective mode of teaching and learning. Its major process is to develop participants an intellect who can win race of advance teaching and learning. Therefore, participants should not miss such an opportunity, which can engage, approaches learning and learning methods, expand interpersonal skills and new perspectives. Hence, it has broad transformational role as method of teaching and learning research education for all in future.

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FEATURES OF THE FORMATION OF A REGIONAL SECURITY SYSTEM IN EASTERN EUROPE

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ABSTRACT

The formation of a new world order is primarily caused by new conditions and military operations on the European continent. The intensification of military-political tension led to the formation of new centers of power and gravity, which in turn led to the concentration of weapons and general militarization. Changes in the world order as a result of military conflicts and an increase in hot spots in the world, an increase in threats and the formation of centers of military gravity, the inability of existing institutions to resolve the situation lead to the need to develop new security mechanisms. The main purpose of the article is to identify the key features of regional militarization in the modern world, to identify key centers for the formation of regional associations, and especially in Eastern Europe. The Methods/Approach of the article is a comparative analysis of regional characteristics and levels of militarization. Conclusions. Studies show that in recent years there has been an increase in the level of militarization of individual countries and the highest level is demonstrated by the countries of Eastern Europe (including the Baltics). This is primarily due to the increase in threats and the escalation of the conflict in Ukraine from Russia, as well as the increase in the intensity of previously unleashed conflicts. The increase in the degree of military-political tension leads to the need to form centers of power that could deter certain forces and threats in the regions. Previously, only weapons of mass destruction were defined as such forces, but in the modern world a new world order is being formed that could ensure the stabilization of the situation in Europe, given the presence of a fairly strong center of military power and the threat from Russia. Militarization trends indicate an increase in the quantity and quality of weapons in a region that could potentially be in the circle of Russia’s geopolitical interests. Studies show that in the current situation, the countries of Eastern Europe and the Baltic countries are especially actively increasing their level of technologization of the army and militarization in general.

Keywords: Innovation, regional security, Baltic-Black Sea Union, security system, prerequisites for the formation

JEL classification: F01, F15, F42

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INTRODUCTION

The formation of the collective security system takes place in the new conditions of world formation. Changes in the world order as a result of military conflicts and an increase in hot spots in the world, an increase in threats and the formation of centers of military gravity, the inability of existing institutions to resolve the situation lead to the need to develop new security mechanisms. In turn, this requires studying the possibilities of individual countries to participate in the formation of regional associations.
Previously unsettled problem constituent. However, the change in the modern world order in view of the Russian invasion and the formation of a new military-political association requires research into the prerequisites and possibilities for such cooperation.

The main purpose of the article is to identify the key features of regional militarization in the modern world, to identify key centers for the formation of regional associations, and especially in Eastern Europe.

LITERATURE REVIEW

Analysis of recent researches and publications. The study of the formation of defense economics is the basis of a significant number of works by the following scientists: Fabrizio Tassinari analyzed the key features of militarization in the European region (Tassinari, 2005); Mustafa Aydín (Aydin, 2005) studied the features of the Eastern European region within the framework of the concept of the Baltic-Black Sea region; Jovana Georgievskaja (Georgievska, 2020) explored the possibilities of building a kind of "shield" in Europe, which will be designed to limit the influence of Russia; the formation of the defense economy is studied in the work of Barry Watts (Watts, 2015); the historical aspects of the formation of the European defense system are studied in the works of Andrew K. Rose and Mark M. Spiegel (Rose & Spiegel, 2009).

RESULTS AND DISCUSSIONS

According to experts (Abuseridze et al, 2022; Jukna & Grasis, 2022), the key prerequisites for the formation of a new world order are the strengthening of political confrontation and, accordingly, the strengthening of militarization in certain regions of the world. It should be noted that individual regions of the world are the most dynamic in increasing the level of militarization, among which Eastern Europe occupies a special place in the modern world, which becomes a bridge of protection against Russian aggression. World experts are trying to assess the level of militarization of countries, their military power, level of training and capabilities in military conflicts. The key indices that assess the potential of countries and regions for military conflicts are the Global Military Power Index and the Global Militarization Index. Each of these indices takes into account the characteristics of the regions and is based on different approaches. Thus, the first index considers the natural indicators of militarization, while the second compares the level of attention to the military sector in relation to medicine.

In general, the key players in the arms market are countries with the highest level of power and security is ensured through the support of global leaders in military affairs, including the United States, Russia, China, India, Japan, South Korea, France, Great Britain, Pakistan, Brazil (Table 1).

One can note a rather high level of dynamism of this index and the absence of certain types of weapons in the index itself, for example, weapons of mass destruction (nuclear, chemical, biological and other types of weapons), including a new type of high-tech.
Table 1. TOP-10 countries according to the Global Fire Power rating

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>USA</td>
<td>0.0453</td>
</tr>
<tr>
<td>2</td>
<td>Russia</td>
<td>0.0501</td>
</tr>
<tr>
<td>3</td>
<td>China</td>
<td>0.0511</td>
</tr>
<tr>
<td>4</td>
<td>India</td>
<td>0.0979</td>
</tr>
<tr>
<td>5</td>
<td>Japan</td>
<td>0.1195</td>
</tr>
<tr>
<td>6</td>
<td>South Korea</td>
<td>0.1261</td>
</tr>
<tr>
<td>7</td>
<td>France</td>
<td>0.1283</td>
</tr>
<tr>
<td>8</td>
<td>Great Britain</td>
<td>0.1382</td>
</tr>
<tr>
<td>9</td>
<td>Pakistan</td>
<td>0.1572</td>
</tr>
<tr>
<td>10</td>
<td>Brazil</td>
<td>0.1695</td>
</tr>
</tbody>
</table>

Source: Author’s own calculation, based on 2022 Military Strength Ranking

In general, the Index includes a significant number of indicators that determine the country's capabilities in one form or another of military activity, in addition, for countries that do not have a water border, the presence of maritime transport is not taken into account, since it does not take part in the formation of the country's military power. In general, the rating analyzes more than 50 individual indicators to assess the military power of the country. At the same time, the indicators quite widely analyze the country's capabilities, from macroeconomic indicators to geographical ones. In this context, the chances of countries are equalized in the format of competition, the lower the indicator, the closer it is to 0, the higher the military potential of the country (2022 Military Strength Ranking).

The key security countries in the Eastern European region are Lithuania, Latvia, Estonia, Poland, Moldova, Ukraine, Romania, Bulgaria, Poland. Russia's military invasion of Ukraine has significantly updated the construction of a new security model, in general, we are talking about building the Baltic Sea - Black Sea model. At the same time, all countries of the Eastern European region occupy fairly high positions in the global ranking of military power, but large countries occupy high positions (Table 2).

Table 2. Positions of individual European countries according to the Global Fire Power ranking

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>Ukraine</td>
<td>0.3266</td>
</tr>
<tr>
<td>24</td>
<td>Poland</td>
<td>0.4179</td>
</tr>
<tr>
<td>38</td>
<td>Romania</td>
<td>0.5938</td>
</tr>
<tr>
<td>52</td>
<td>Belarus</td>
<td>0.8169</td>
</tr>
<tr>
<td>67</td>
<td>Bulgaria</td>
<td>1.1071</td>
</tr>
</tbody>
</table>
As we can see in the global index, individual countries of Eastern Europe (including the Baltics) do not occupy the highest positions, however, it is worth noting that the countries are quite small and cannot represent great power at the global level, however, the dynamics of strengthening their positions is clearly visible when analyzing the Global Index militarization (GMI), which is researched and developed by the Bonn International Center for Conflict Studies (Global Militarization Index, 2020). This index assesses the level of military spending and GDP and health care spending. Thus, the total number of armed forces is compared with the number of doctors, and the object of study is the quantity and quality of heavy weapons (Global Militarization Index (a), 2020).

It is worth noting that the presence in the region of a large militarized player, which is Russia, which poses a threat both in the military and political dimensions, contributes to an increase in the level of militarization of countries that are in a potential circle of conflict, especially post-Soviet ones (Fig. 1).

![Figure 1. Dynamics of the positions of regions in the Global Militarization Index, 2021](image)

*Source: Author’s own calculation, based on Global militarisation index 2021 (Bayer, 2021)*

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1 Baltic countries: Estonia, Latvia, Lithuania; Northern Europe: Denmark, Finland, Sweden; Eastern Europe: Bulgaria, Croatia, Poland, Romania, Slovakia, Slovenia, Czech Republic, Hungary; Central, Western and Southern Europe: Belgium, Germany, France, UK, Greece, Italy, Ireland, Luxembourg, Malta, Netherlands, Austria, Portugal, Spain
We can note that the Baltic countries demonstrate the greatest dynamics and increase in the level of militarization, the countries of Eastern Europe are in second place in terms of dynamics. However, the presence of a sufficiently strong aggressive country like Russia contributes to the growth of militarization and the level of weapons in the bordering countries. For example, Finland improved its position from 33rd to 29th place, which is facilitated by the presence of more than 1000 km border with Russia, having spent more than 4.1 billion dollars on armaments in 2019. (1.5% of GDP), however, Finland has planned an increase in funding by 41% (2 billion dollars), primarily for the purchase of fighter jets and heavy weapons. At the same time, Norway invested more than 7.4 billion dollars in weapons systems and the army, which is 1.7% of GDP (increasing its figures compared to 2014, when spending was 1.5% of GDP), which were spent, including for the purchase of heavy weapons systems (increasing their number to more than 800), fighters (F-35), armored personnel carriers. Moreover, in 2020, Sweden adopted the Defense Law, which is designed to protect and strengthen the readiness to defend the country from an aggressor Russia, given the growing tension and confrontation in the waters of the North Atlantic, the Baltic Sea, as well as in the airspace over Scandinavia. In general, Sweden decided to increase the military budget by 40% by 2025 and to purchase the latest weapons systems, fighters, submarines, cyber defense and cyber troops, although in 2010 Sweden abolished the mandatory conscription into the army (Cancellation of conscription into the army, 2009), however, already in 2018, this provision was revised towards the resumption of conscription and an increase in the reserve by 10 thousand people, by 2035 the number of troops should be increased by 30 thousand active soldiers (Sweden Returned Conscription Due to The Russian Threat, 2017).

There is also an increase in the level of militarization throughout the Eastern European region, programs have been launched to strengthen government orders and purchases, modernize the army and equipment, switch from Soviet weapons standards to NATO standards, the Czech Republic has improved its position from 98th to 89th place since 2014, including through investment in military equipment, vehicles (infantry, light combat, helicopters, radar systems). Hungary moved from 92nd to 78th place, having improved its air defense systems, increasing the number of missiles, combat helicopters and transport, self-propelled howitzers, battle tanks. Romania improved its position from 46th to 36th place, including through the purchase of new fighters and armored personnel carriers, increasing military spending from 1.3% to 2%. Slovakia moved up from 79th to 64th place and increased spending to 1.8% of GDP in 2019 from 1.0% in 2014. Bulgaria moved up 20 positions from 60th to 40th place, offering the army 3.2%, up from 1.2 % in 2014. A similar strategy was implemented in Croatia, which moved from 53rd to 44th place, which was facilitated by the purchase of heavy weapons systems and an increase in army personnel and reserves (Mutschler & Bales, 2020).

A fairly high level of militarization also remains in Belarus, which ranks 17th, with almost 50,000 active soldiers, 110,000 paramilitaries and about 290,000 reservists, with a total population of 9 million people. Belarus imports the bulk of weapons from Russia, military budget expenditures amount to 1.2%.
Ukraine also significantly increased the level of militarization, ranking 6th in Europe in 2021, increasing its military spending by 9% (5.9 billion dollars), in 2020 the level of spending was 4.1% of GDP for 209 thousand militaries. This led to an improvement in the position of Ukraine by 3 points in 2020, it is worth noting that since 2014 the country has risen from 41st place in the world ranking to 19th in 2020. Ukraine has significantly increased the number of military and paramilitary personnel, modernized weapons systems, increased the budget by 62 % to the amount of 4.6 billion dollars. in 2019, which amounted to 3.4% of GDP (in 2014 it was 2.2%).

The active party to the conflict in the Donbas is Russia, which ranks 8th in terms of the level of militarization. Russia owns one of the largest armies in the world, which includes more than 70,000 heavy weapons systems and about a million soldiers, as well as 2 million reservists. The peak value of government spending on the maintenance of the army reached in 2016, but in 2017 and 2018 they significantly decreased. It is worth noting that in 2019 spending on the maintenance of the army increased significantly (64.1 billion dollars or 3.9% of GDP) (Mutschler & Bales, 2020), which may be evidence of preparations for an invasion of Ukraine. In 2020, Russia's spending on the army decreased slightly and amounted to 62.7 billion dollars. (Bayer, 2021). Russia is investing heavily in modernizing its air force and has upgraded more than two-thirds of its weapons systems since 2008. An alarming factor is the renewal of the strategic nuclear forces. Experts note that the army in 2019-2020 was at the highest level since 1992, which was the result of the purchase of high-precision weapons and automated command and control systems. Network-centric control systems have also been formed, which is a combination of automated electronic control systems, information collection and processing (Network Centric Operations: Background and Oversight Issues for Congress, 2007). A high level of training has already manifested itself in the wars in Libya, Syria, Ukraine, over the past decade, more than 684 billion dollars have been spent on these wars. It is planned to upgrade for another 306 billion dollars. as part of the GPV 2027 program, where, among other things, it is planned to purchase another 76 Su-57 fighters. It was also planned to strengthen the naval forces, but the sanctions destroyed the opportunity to receive ships from France. It should be noted that in Europe the most militarized countries are Armenia, Russia, Greece, Cyprus, Azerbaijan, Belarus, Montenegro, Turkey, Ukraine and Finland (Table 3).

<table>
<thead>
<tr>
<th>Country</th>
<th>global Expenditure Index</th>
<th>global Personnel Index</th>
<th>global Heavy Weapons Index</th>
<th>GMI value</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armenia</td>
<td>2.2 3.1</td>
<td>1.7 1.9</td>
<td>2.3 2.4</td>
<td>310.1 377</td>
<td>2</td>
</tr>
<tr>
<td>Russia</td>
<td>2.1 3.2</td>
<td>0.9 0.9</td>
<td>2.7 2.8</td>
<td>285.1 353</td>
<td>8</td>
</tr>
<tr>
<td>Greece</td>
<td>1.6 2.3</td>
<td>1.1 1.2</td>
<td>2.7 2.7</td>
<td>269.1 318</td>
<td>12</td>
</tr>
<tr>
<td>Cyprus</td>
<td>1.2 1.8</td>
<td>1.5 1.6</td>
<td>2.7 2.8</td>
<td>268.2 316</td>
<td>13</td>
</tr>
</tbody>
</table>
Russia regularly conducts military exercises along with China, Pakistan, Belarus, Armenia and Myanmar. At the same time, the EU and NATO countries are conducting their multilateral exercises, the total number of personnel involved can reach 37 thousand military personnel. In 2020, such exercises were limited due to the coronavirus pandemic. Relations between NATO countries and Russia deteriorated due to Russia’s aggression against Ukraine, the annexation of Crimea and the military conflict in the eastern regions. In general, tensions in relations between Russia and NATO have been constantly growing in recent years, which is also related to previous conflicts. Thus, in 2021, in the Black Sea, Russian forces announced that they fired warning shots at a British destroyer, which, according to Russia, violated territorial waters, but the destroyer was near Crimea, which is recognized as Ukrainian in international law (Russia claims to have opened fire on the course of the British destroyer Defender, Britain denies this, 2021). The confrontation continued during military exercises that were held by both Russia and NATO, the latter held DEFENDER-Europe 21, in which military personnel from 26 countries were involved (in total, more than 28 thousand military). Russia, together with Belarus, held "West-2021", in which about 200 thousand soldiers and about 300 tanks took part, the main purpose of which was to test the level of defense capability of Belarus and Russia.

We can see an increase in the level of militarization in the region, which ultimately led to an open war between Russia and Ukraine in 2022. In general, three countries in Eastern Europe are in the top 10 most militarized countries in the world, and three more are included in the top 20. In the European Union, militarization has increased in 22 out of 27 countries since 2014, moving the average EU Militarization Index in 2019 by 10 positions (from 82 in 2014 to 72 in 2019). An increase in the level of militarization can also be observed in the Baltic countries, so Latvia in 2014 ranked 129th, in 2019 the country took 60th place, significantly improving its performance. Lithuania has increased its position by 50 points (from 82 in 2019 to 32 in 2019). Both countries have significantly increased their spending on military needs, and if in 2014 they invested 0.9% of GDP, then in 2019 this figure is 2%. Estonia improved its position during this period by 10 places (from 42 to 32) and increased by 0.2% in spending (from 1.9% in 2014 to 2.1% in 2019). In general, for NATO countries, military spending is 2% (Mutschler & Bales, 2020).

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</tr>
</thead>
<tbody>
<tr>
<td>Azerbaijan</td>
<td>2.1</td>
<td>4.1</td>
<td>0.9</td>
<td>0.6</td>
<td>2.1</td>
<td>2.1</td>
<td>254.8</td>
<td>389</td>
</tr>
<tr>
<td>Belarus</td>
<td>1.0</td>
<td>1.4</td>
<td>1.4</td>
<td>1.5</td>
<td>2.3</td>
<td>2.3</td>
<td>231.8</td>
<td>269</td>
</tr>
<tr>
<td>Montenegro</td>
<td>1.0</td>
<td>1.9</td>
<td>1.5</td>
<td>1.5</td>
<td>1.3</td>
<td>1.6</td>
<td>226.4</td>
<td>258</td>
</tr>
<tr>
<td>Turkey</td>
<td>1.8</td>
<td>2.7</td>
<td>0.7</td>
<td>0.7</td>
<td>2.0</td>
<td>2.0</td>
<td>223.8</td>
<td>278</td>
</tr>
<tr>
<td>Ukraine</td>
<td>1.9</td>
<td>3.0</td>
<td>0.8</td>
<td>0.5</td>
<td>1.8</td>
<td>1.9</td>
<td>221.6</td>
<td>305</td>
</tr>
<tr>
<td>Finland</td>
<td>1.1</td>
<td>0.7</td>
<td>2.3</td>
<td>2.3</td>
<td>203.0</td>
<td>29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estonia</td>
<td>2.1</td>
<td>0.6</td>
<td>2.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Author’s own calculation, based on Global militarisation index 2020 (Mutschler & Bales, 2020)
It is worth noting that the economy of the military sector makes up a fairly large part of government spending, the study of financial investments in the military sector is actively conducted by SIPRI based on open resources. In general, we can note that the largest amount of financial resources in the military sector is concentrated in North America, compared with other regions of the world, which was noted, but not taken into account in the GIM (table 4).

**Table 4. Military expenditure in Europe in constant US dollars, 2021**

<table>
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<tr>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>World total (including Iraq)</td>
<td>1022</td>
<td>1443</td>
<td>1790</td>
<td>1767</td>
<td>1774</td>
<td>1796</td>
<td>1842</td>
<td>1909</td>
<td>1960</td>
</tr>
<tr>
<td>World total (excluding Iraq)</td>
<td>1440</td>
<td>1785</td>
<td>1758</td>
<td>1768</td>
<td>1789</td>
<td>1836</td>
<td>1902</td>
<td>1953</td>
<td></td>
</tr>
<tr>
<td>Europe</td>
<td>285</td>
<td>303</td>
<td>330</td>
<td>336</td>
<td>348</td>
<td>339</td>
<td>346</td>
<td>363</td>
<td>378</td>
</tr>
<tr>
<td>Central Europe</td>
<td>17.7</td>
<td>20.2</td>
<td>19.5</td>
<td>22.3</td>
<td>22.6</td>
<td>24.4</td>
<td>27.5</td>
<td>31.1</td>
<td>33.0</td>
</tr>
<tr>
<td>Eastern Europe</td>
<td>25.3</td>
<td>38.2</td>
<td>54.5</td>
<td>82.4</td>
<td>87.0</td>
<td>71.9</td>
<td>70.5</td>
<td>74.3</td>
<td>76.8</td>
</tr>
<tr>
<td>Western Europe</td>
<td>242</td>
<td>244</td>
<td>256</td>
<td>231</td>
<td>239</td>
<td>243</td>
<td>248</td>
<td>258</td>
<td>268</td>
</tr>
</tbody>
</table>

*Source: (SIPRI Arms Industry Database, 2021)*

Overall, North America accumulates the highest amount of military complex funding, followed by East Asia in second place by region, followed by Western Europe. Thus, we can note the formation of key centers of military power, which, in turn, are characterized by the presence of centers of gravity, which are countries with the highest level of funding for the military sector (table 5).

**Table 5. Military expenditure by country, in constant (2019) US$ m., SIPRI 2021**

<table>
<thead>
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<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>475217</td>
<td>698019</td>
<td>865268</td>
<td>683678</td>
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<td>674557</td>
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<td>734344</td>
<td>766583</td>
<td>778232</td>
</tr>
<tr>
<td>Russia</td>
<td>23584</td>
<td>35165</td>
<td>49834</td>
<td>74649</td>
<td>80027</td>
<td>64848</td>
<td>62404</td>
<td>65201</td>
<td>66838</td>
<td>61713</td>
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<tr>
<td>Poland</td>
<td>5350</td>
<td>6534</td>
<td>7887</td>
<td>10594</td>
<td>10007</td>
<td>10233</td>
<td>11591</td>
<td>11786</td>
<td>12815</td>
<td>13027</td>
</tr>
<tr>
<td>Ukraine</td>
<td>1185</td>
<td>1847</td>
<td>2239</td>
<td>3905</td>
<td>3990</td>
<td>3988</td>
<td>4744</td>
<td>5419</td>
<td>5995</td>
<td>5924</td>
</tr>
<tr>
<td>Romania</td>
<td>1857</td>
<td>2272</td>
<td>1939</td>
<td>2647</td>
<td>2793</td>
<td>3789</td>
<td>4214</td>
<td>4613</td>
<td>5579</td>
<td>5727</td>
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<tr>
<td>Czech</td>
<td>2916</td>
<td>3413</td>
<td>2423</td>
<td>2069</td>
<td>2243</td>
<td>2240</td>
<td>2641</td>
<td>2910</td>
<td>3187</td>
<td>3252</td>
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<tr>
<td>Hungary</td>
<td>1461</td>
<td>1734</td>
<td>1176</td>
<td>1189</td>
<td>1358</td>
<td>1473</td>
<td>1721</td>
<td>2051</td>
<td>2463</td>
<td>2410</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>871</td>
<td>946</td>
<td>806</td>
<td>686</td>
<td>734</td>
<td>761</td>
<td>940</td>
<td>2159</td>
<td>1210</td>
<td>1247</td>
</tr>
<tr>
<td>Lithuania</td>
<td>290</td>
<td>417</td>
<td>326</td>
<td>523</td>
<td>701</td>
<td>852</td>
<td>1025</td>
<td>1094</td>
<td>1135</td>
<td>1171</td>
</tr>
<tr>
<td>Belarus</td>
<td>186</td>
<td>384</td>
<td>556</td>
<td>710</td>
<td>668</td>
<td>642</td>
<td>730</td>
<td>774</td>
<td>785</td>
<td>845</td>
</tr>
<tr>
<td>Latvia</td>
<td>134</td>
<td>397</td>
<td>256</td>
<td>310</td>
<td>447</td>
<td>507</td>
<td>692</td>
<td>739</td>
<td>757</td>
<td></td>
</tr>
<tr>
<td>Estonia</td>
<td>175</td>
<td>284</td>
<td>343</td>
<td>513</td>
<td>551</td>
<td>567</td>
<td>597</td>
<td>637</td>
<td>687</td>
<td>701</td>
</tr>
<tr>
<td>Moldova</td>
<td>15.1</td>
<td>22.1</td>
<td>21.7</td>
<td>30.6</td>
<td>36.3</td>
<td>35.5</td>
<td>37.9</td>
<td>43.0</td>
<td>43.1</td>
<td>44.5</td>
</tr>
</tbody>
</table>
As we can see, the United States of America has the highest spending on weapons, while they are ahead of China, which is in second place, more than three times, and spending is 10 times higher than, for example, Russia. At the same time, even in relative terms, for example, as a share of GDP, the United States is significantly ahead of all other countries, and given the size of the US GDP, we can note that financing is at an extremely high level.

CONCLUSIONS

The increase in the degree of military-political tension leads to the need to form centers of power that could deter certain forces and threats in the regions. Previously, only weapons of mass destruction were defined as such forces, but in the modern world a new world order is being formed that could ensure the stabilization of the situation in Europe, given the presence of a fairly strong center of military power and the threat from Russia. Militarization trends indicate an increase in the quantity and quality of weapons in a region that could potentially be in the circle of Russia's geopolitical interests. Studies show that in the current situation, the countries of Eastern Europe and the Baltic countries are especially actively increasing their level of technologization of the army and militarization in general.

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The author has read and agreed to the published version of the manuscript.

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MODEL OF ENSURING ECONOMIC SECURITY IN MECHANICAL ENGINEERING

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ABSTRACT

Industry as a strategic sector of the economy is an important structural element of the economic security of the state, whose performance indicators are a priority for determination of the level of economic development of the country. It forms the foundation for research and technological transformation, economic growth, and social progress in society. The formation of tools for ensuring the economic security of the state based on the improvement of the machine-building complex and the elimination of threats to economic security involves: a) the creation of a centralized system for ensuring the economic security of the state from the standpoint of mechanical engineering; b) the identification of structural imbalances containing a threat to the economic security of the state; c) the development of tools to ensure the economic security of enterprises by influencing the structural imbalances in mechanical engineering at all levels.

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INTRODUCTION

Mechanical engineering is traditionally considered the basis of the national economy and plays a leading role in creating the material and technical basis for all of its industries. The level of development of mechanical engineering is considered one of the important indicators of the economic condition of the country and one of the main indicators for assessing its economic security. Its exclusive role is to implement innovative, science-intensive projects in all sectors of the economy and is defined in the concept of a nationwide target economic program for the development of industry, where it was noted that the pricing environment for the main export positions and the demand for products of the engineering industry have a decisive influence on the situation in the industry (Fig. 1).
In 1990, the share of engineering products was 32% of GDP (State Statistics Service of Ukraine, 2021). However, the domestic engineering industry continues to decrease in parallel with its scientific and technical degradation.

![Index of industrial production of mechanical engineering of Ukraine in 2006 - 2021 (in % to the previous year)](https://journal.access-bg.org/)

**Figure 1.** Index of industrial production of mechanical engineering of Ukraine in 2006 - 2021 (in % to the previous year) (State Statistics Service of Ukraine, 2021).

The management of the economic security of the machine-building complex ensures the effectiveness of the activities of machine-building enterprises in the current period of their operation and in the long term. At the same time, effective management in any field of activity can be carried out only when its integral system is formed, designed to perform the main tasks of management. Therefore, a necessary condition for ensuring the functioning of machine-building enterprises in a market economy is the allocation of vectors for improving the economic security of the country's machine-building complex.

Management of economic security at the strategic, tactical and operational levels makes it possible to prevent the destructive impact of changes in the factors of the internal and external environment of the enterprise and prevent their decrease to a level within which the machine-building enterprise cannot function without a threat to the stability of its activities.

At the same time, the problem of choosing a priority among certain vectors of enterprise development and matching the strategy to internal production processes, namely: the policy of managing the renewal of fixed assets, technical and technological re-equipment, the introduction of innovations, the system of motivation and development of personnel, and the environmental friendliness of production, is of particular relevance (Chekhovych, 2013).
THEORETICAL BACKGROUND

Modern threats to the activities of enterprises in the machine-building complex cause the promotion of fundamentally new requirements for the construction and organization of the activities of their security systems. In order to counter modern threats and risks, the directions for increasing the level of economic security of enterprises should take into account modern technologies, methods and techniques for actively counteracting all real and potential dangers and risks.

The mechanism for managing the economic security of enterprises of the machine-building complex is created to ensure the correct use of all protective measures in order to minimize (or prevent) the negative impact of hazards, threats, and risks. The management mechanism is manifested primarily with the help of management relations, implemented through the use of appropriate methods based on the principles of management (Chekhovych, 2013). An important part of the stabilization of the economic activity of enterprises in market relations is economic activity in ensuring safety. The development of economic activity is a significant factor in improving the efficiency of economic security. The problems of improving the efficiency of economic activity of enterprises have always been the focus of economists' attention. The theoretical and methodological basis of this study is the main provisions and conclusions formulated in the scientific fundamental works of domestic and foreign economists in the fields of economic and financial analysis, financial management, and marketing. The issues of the functioning of the economic activity of an enterprise are widely covered primarily in foreign scientific literature (Okawa, 2008; Boyk, 2019; Sousa et al., 2021). In Ukraine, these problems are dealt with by such specialists as Rudnichenko et al. (2020), Zhuravlov et al. (2020), Nazarova et al. (2021), Flissack, Dracocrunch (2021).

The purpose of the article is to identify the main ways to improve the economic activity of enterprises in the context of a model for ensuring economic security in mechanical engineering.

RESULTS AND DISCUSSION

The problems of improving the economic security of the machine-building complex have always been quite relevant, but since 2009, that is, after the end of the global financial crisis, there has been an urgent need to form new vectors for ensuring the economic security of the machine-building complex in order to take into account the influence of the maximum number of destabilizing factors in the future. This will allow the development of a set of measures to achieve a high level of competitiveness for business entities. Only systemic provision of the economic security of the machine-building complex will contribute to the development of enterprises and the achievement of their planned indicators (Fig. 2). In the case of the implementation of systemic economic security, the components of engineering enterprises will be able to stabilize the level of economic security, which will manifest itself in countering the effects of destabilizing factors and which will achieve economic efficiency, that is, get a positive result from the invested resources and the implementation
of actions. At the same time, it will help enterprises obtain competitive advantages and form a stable position in the market.

### Figure 2. The main components of ensuring the economic security of the machine-building complex

Source: Chekhovych, 2013

The entire process of systemic ensuring the economic security of engineering enterprises is built on the activities of economic entities to determine the manifestations of destabilizing factors and develop measures to eliminate them, minimize their impact, or prevent the action of these factors (Chekhovych, 2013).

Accordingly, on the basis of the collected and analyzed information, the subjects of ensuring the economic security of enterprises in the machine-building complex should form the strategy and tactics of the enterprise to increase its level of economic security. Strategic planning is understood as a process of modeling the effective activity of engineering enterprises for a certain period of operation with the definition of their goals and their changes in an unstable market environment and finding a way to implement these goals and objectives in accordance with their capabilities.

The strategic plan helps to form a holistic view of the organization and its goals and determines priorities. It allows you to increase the efficiency of using the strengths of a machine-building enterprise and to coordinate its development with ongoing changes in the environment.

Despite the rather weighty advantages of strategic planning, domestic machine-building enterprises practically do not carry it out. This is largely due to the fact that the leaders of such business structures do not realize their advantages and do not have experience in their implementation. A specific factor complicating strategic planning is the instability of the external environment. It leads to the fact that strategic planning takes
into account information about the state of the internal environment while the state of the external environment is ignored (Chekhovych, 2013).

The process of systematic ensuring the economic security of enterprises in the machine-building complex is based on the activities of economic entities and consists of determining the manifestations of destabilizing factors and the formation of measures to eliminate them, reduce their influence or avoid the action of these factors. Taking this into account, the initial component is the activity of the subjects ensuring the economic security of enterprises in the machine-building complex. They form the concept of economic security for enterprises of the machine-building complex, where the distribution of functions between them is clearly carried out and a list of goals is drawn up that is intended to be achieved in the process of implementing the above functions. The work of the subjects on the comprehensive provision of economic security for enterprises of the machine-building complex begins with the collection of information and diagnosis of the influence of destabilizing factors and opportunities that create the internal and external environment. Comprehensive provision of economic security for enterprises of the machine-building complex requires thorough information support for assessing the state of the internal and external environments, making decisions at the appropriate level in the interests of the functioning of the enterprise, and reducing the level of uncertainty in the prospects for its activities (Ponomarenko et al., 2019) The algorithm for studying destabilizing factors and the possibilities of the internal and external environments of the enterprise is as follows:

1. Identifying the external and internal environments that affect the enterprise and influence it in the strategic period.
2. Collection of information about these factors
3. Evaluation of the information received about each factor of the environmental impact on the enterprise and forecasting the magnitude of the possible impact.
4. Assessment of the magnitude of the influence of each factor on the enterprise in the strategic period, resulting in the identification of opportunities and threats to the external and internal environments and strengths and weaknesses (Chekhovych, 2013).

The above mechanism for creating such a system of measures should take into account a number of fundamental features that reflect the high competitiveness of the industry and the possibility of eliminating negative crises in the economy (Yepifanova, 2019). Priority of mechanical engineering's innovative development goals Any transformation of the industry must take into account the interests and goals of foreign markets. At the present stage, the speed and efficiency of production, implementation, and dissemination of innovations, which is due to the "demand challenge" or "technological push", determine the basic direction for the modernization of the high-tech machine-building complex. Therefore, the content and results of the implementation of this process should acquire an innovative character, and the proposed support measures should focus the modernization of mechanical engineering on innovative development.

Perspective and innovativeness will determine the continuous renewal of the industry based on modern methods and models of economic growth. The best samples of equipment, technologies, and other products
are a criterion for the competitiveness of enterprises in the markets and the effectiveness of modernization processes.

Actually, the standard for the efficiency of modernization of mechanical engineering is a leading comparison base (the best technical, technological, organizational, and other world standards). Thus, the system of measures for the development of modernization should focus on determining the priorities for the development of mechanical engineering with the identification of points of growth or points of application of efforts. The factor that determines the trend of technology modernization is the high wear and tear of production facilities, which cannot provide the required quality, labor productivity growth, and resource-saving. Technological and product modernization is due to the low competitiveness of engineering products. The latest technological innovations are distributed to a limited number of manufacturers and developers who own their own production base, experience, and resources. Accordingly, this requires the development of mechanisms for their implementation. Technological modernization can be achieved through the following channels: investments; acquisition of licenses and patents; creation of integrated innovative forms of business organization; etc. The reaction to technological and product modernization is the modernization of organizational, managerial, monetary, marketing, and other actions.

Therefore, measures to support modernization in mechanical engineering should provide for obtaining long-term results—achieving high business performance and ensuring the long-term life cycle of enterprises, which guarantees their sustainable development. Product, technical, and technological leadership in this industry creates a reserve for maintaining the competitiveness of enterprises, the level of which other market participants often fail to overcome. Therefore, the principle of priority determines the need to support the development of the modernization potential not only of leading enterprises but also of outsider enterprises in the industry market.

Consistency involves considering modernization as an elemental structure, a specific organization with a set of functions in conjunction with other economic phenomena and processes. The concept of consistency is associated with the idea of integrity, which is squeezed out in the provision of mechanical engineering with all the elements necessary for modernization, their qualitative certainty and quantitative sufficiency, connectivity and consistency of interelement relationships or self-organization.

This approach allows considering mechanical engineering not only as an element of a higher level system, but also as an independent system in which various objects and subjects exist as a whole to ensure their purposeful and coordinated activities in the process of modernization in accordance with the functional relationships between them in order to achieving harmonization of interests. In this system, three main elements related to modernization can be distinguished, in particular: the resource provision of modernization, its implementation or organizational design, and the efficiency of using the results obtained. These elements constitute the content of targeted sectoral development programs or modernization programs, the preparation of which should be taken into account in the system of measures to support it (Adamu, Dawha, Kamar, 2015).
Thus, the system of measures to support modernization should help create a basis for the development of innovations, long-term economic growth, and ensure competitive advantages in mechanical engineering. The multivariance and probabilistic nature of modernization, as its important features, require more detailed consideration. There are many options for modernization, namely: from the standpoint of the novelty of the results obtained and the resources (Chekhovych, 2013).

Along with this important vector of improving the economic security of the machine-building complex, we also consider the improvement of the regulatory framework (Kuznyetsova et al., 2021). The current legal system in Ukraine hinders the development of the innovation environment:

- does not change the systemic tax policy in this area, which stimulates the implementation of innovations;
- formed on the basis of conservation and protection, and not the development and use of the capabilities of knowledge-intensive enterprises.

Therefore, it is necessary to develop a number of legislative acts, within which, first of all, it is necessary to determine: the possibilities of tax incentives for the creation, implementation, and dissemination of innovations; opportunities for the commercialization of intellectual property (a system for managing rights to the result of scientific and technical activities; business access to projects that are directly in the field of public administration and responsibility; and the latest technological basis, in particular nanotechnologies).

Support and regulation of modernization in mechanical engineering can be guided by institutional reforms, which are based on the ideas of an effective owner with the nationalization or denationalization of enterprises, the creation of state corporations, the strengthening of the rule of law, the fight against corruption, etc.

At the same time, it is necessary to provide for the formation of state support mechanisms in the legislation aimed at protecting the national producer in the foreign and domestic markets by: developing measures to prevent unfair competition from foreign countries (dumping prices for domestic products); ensuring competitive conditions for a domestic manufacturer in relation to foreign competitors (primarily in lending, providing comprehensive services, etc.); the formation of mechanisms for accumulating budgetary funds allocated to support agriculture, the construction industry, the development of housing and communal services, etc. (Adamu, Dawha, Kamar, 2015).

Consequently, at the state level, the boundaries of industrial, innovation, and scientific and technological policy in the field of mechanical engineering are determined and conditions favorable for the modernization of the complex are created.

At the regional level, when developing measures to initiate the implementation of modernization, it seems necessary to study the possibilities of reindustrialization of the economy and the formation of innovative forms of business, draw up appropriate programs, and prepare territorial laws on innovatively active industrial policy. Of particular relevance is the development of integrated software approaches to the modernization and improvement of the economic security of the machine-building complex. An effective and modern method that enables the achievement of high efficiency in the machine-building complex through the rational use of
installed capacities and available resources is the development of industrial cooperative ties. At the level of local self-government, the policy of modernization in times of crisis should be aimed at the widespread use of the potential of the spatial organization of production based on the cluster integration of production and territorial capabilities. In addition, it is necessary to continue working with business entities to monitor crisis phenomena, re-profiling human resources and compiling anti-crisis programs.

Accordingly, directions for improving the economic security of mechanical engineering should include mechanisms for regulating and supporting the modernization of the mechanical engineering complex with an emphasis on economic recovery. First of all, they should include: a) ensuring the active and versatile activities of the state and the effective operation of the relevant government bodies at different levels; b) achieving the intensity of market self-regulation; i) formation of relations between engineering enterprises and the state; G) development of the system "state-science-education-business"; e) conducting the policy of large financial institutions and the banking sector.

A rational combination of modernization strategies from above and below will provide an integrated approach to solving the problems of economic security, which means it will allow the formation of an effective mechanism for the sustainable development of machine-building enterprises. In order to use the existing potential of the machine-building complex, it is necessary to develop an effective structural policy in machine-building and related high-tech industries that would meet modern conditions and could ensure a systematic and multifaceted transformation process, which involves further research and improvement of existing mechanisms for managing the potential of machine-building enterprises.

The results of the conducted studies allow us to assert that the difficulties in achieving the economic security of the state from the standpoint of mechanical engineering are due not only to the imbalance in the structure of the national economy and the unfavorable conditions for the expansion of economic activity and the modernization of the production base in all sectors, but also the underdevelopment and inefficiency of the mechanisms for implementing the structural policy of the state.

At the present stage, the following interrelated goals should be attributed to the main vectors for improving the machine-building complex:

- ensuring domestic production's high competitiveness in both domestic and foreign markets, and creating appropriate conditions for increasing the share of industries focused on product production to a high degree;
- alignment of structural deformations accumulated in the national economy, manifested in the restructuring of unprofitable sectors of the economy (with a preliminary analysis of the need for their restructuring from the standpoint of maintaining the state's economic security), which are not in demand, and debts on payments to natural monopolies and tax payments;
- completion of the process of transformation of the existing inefficient institutions of the transitional economy, including the structure of financial and commodity financial markets, state ownership and the system of state regulation, innovative mechanisms, etc., into institutions that meet the needs of the modern economy;
- assistance in the accelerated development of the economic system, markets and enterprises in the process of global economic transformation, which takes place on the basis of the creation of a new technological basis, the introduction of information technologies and the strengthening of regional and global integration processes.

It is necessary to develop a clear strategy of state policy, which would be based on the gradual transformation of the structure of the national economy based on the existing advantages of industries that are competitive in the international market, with the consistent growth of related industries and other economic complexes (Adamu, Dawha, Kamar, 2015).

State policy in this context should be guided by the priority development of those areas of the national economy whose products are in demand not only in the domestic but also in foreign markets. It is important that such an approach envisages both the development of the so-called "traditional" export-oriented industries (primarily the raw materials sector) and the modernization of "new" export industries (primarily processing industries) and service sectors.

Obviously, in order to ensure the economic security of the state, it is necessary to conduct a structural policy of the state that can eliminate the negative impact of structural imbalances that have formed in the national economy of Ukraine. However, the current principles of state policy are not closely related to the goals of ensuring economic security. Therefore, it is necessary to form general principles for the implementation of state policy for the purposes of ensuring national economic security at all levels:

1) the national level - the creation of a centralized mechanism for the implementation of structural policy; agreeing on goals to achieve sustainable economic growth and economic security;

2) the territorial level - the development and implementation of regional targeted programs that focus on ensuring the economic security of the state and are in strict coordination with state policy;

3) sectoral level - the formation of priority and competitive industries and directions for the implementation of state policy for the purpose of ensuring economic security based on the use of a combination of raw materials and innovative models of economic development;

4) micro level - the formation of conditions for the integrated development of business structures in priority sectors and areas of the economy.

The development of industry is the creation of conditions for the import substitution of innovative products and food products, the development of manufacturing industries, and the increase in the scientific and technical potential of domestic engineering in order to overcome the catastrophic redistribution between the industrial sector, the service sector, and the banking capital circulation sphere. A policy to smooth out structural disproportions at all levels of the national economy must necessarily include measures to overcome certain problems in the most significant branches of industry.

Obviously, in the context discussed above, the goal of state policy in the field of industry should be to increase the competitiveness of products manufactured in all sectors, to achieve a technical level of production that meets global standards, and to ensure the stability of the domestic real sector against domestic ones (in
In this case, structural imbalances should be understood) between the real and banking sectors and the service sector and intra-industry disproportions) and external (economic and political instability at the international level) threats to economic security and creating conditions for the development of Ukraine’s industry in the direction of import substitution and innovatively active industrial production to ensure its stable and sustainable economic growth.

It is necessary that the so-called dual-use technologies become the most widespread, which include: technologies for obtaining new materials; information technologies; microelectronics; technologies of highly efficient heat engines; biotechnology; high-performance industrial equipment; equipment for environmental protection; and unique technologies for experimental development and testing of complex systems.

Thus, in general, comprehensive measures for the development of industry will contribute to the modernization of individual technologies and production links (especially in the manufacturing industries), increase the level of the technological component at each enterprise and the introduction of advanced modern quality systems, certification of production and products. Ultimately, the implementation of these areas will lead to the sustainability of domestic industrial production and the achievement of positive shifts in the economy, which will be associated with an increase in the share of products manufactured by processing industries compared to extractive industries and an increase in the share of science-intensive and high-tech products in the structure of GDP; micro level - creating conditions for the systematic development of business structures in priority sectors and areas of the economy (financial, tax, consulting, property, scientific and technical) to overcome the gap in the level of development and technical equipment of enterprises in various industries and territories.

Due to the presence of a technological gap, business entities in various industries differ from each other in terms of the level of development of production technologies and the level of labor productivity. In addition, there is a serious problem associated with the discrepancy between the supply of technologies from the domestic research and development sector and the needs of companies in technological modernization. As a result, enterprises in our country are increasingly focusing on in-house research and development, only adapting imported technologies to the specific needs of the company, or exclusively on international developments (Table 1).

<table>
<thead>
<tr>
<th>Main Categories / Technologies</th>
<th>Importance index</th>
<th>Business demand</th>
<th>Science proposal</th>
<th>Business Participation Format</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mathematical modeling, methods of management and control of technological processes in</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer technologies and simulation modeling for processing the results of monitoring and restoring a complete picture of the working conditions of the structure</td>
<td>60.4</td>
<td>2012-2017</td>
<td>2019</td>
<td>Private and public partnership</td>
</tr>
</tbody>
</table>
Intelligent systems for monitoring, diagnostics and automatic control of equipment and operating modes of power systems, "commercial dispatching"

| New materials, technologies, manufacturing, etc.                      | 2012-2017 | 2019             | Funding already in progress |
|---------------------------------------------------------------------|-----------|-----------------|
| Materials and coatings for extreme operating conditions             | 82.7      | 2020            | Funding already in progress |
| High-performance polymeric, heat-insulating, heat- and fire-resistant materials, coatings and modifiers. | 76.1      | 2018            | Funding already in progress |

| Energy saving                                                      | 2012-2017 | 2018             | |
|---------------------------------------------------------------------|-----------|-----------------|
| Solar energy converters with an energy conversion efficiency of at least 20 % | 84.6      | 2018            | Not ready |
| Thermoelectric current sources with a power of more than 500 W are autonomous or designed for complex heat recovery. | 70.4      | 2018            | There is not |

Therefore, it is necessary to stimulate domestic enterprises in the real sector of the economy to innovate, which serves as an important instrument of state policy. To do this, it is necessary to ensure their gradual entry into new international markets. After all, international standardization is considered one of the effective methods of increasing competitiveness and the technical level of industrial production. Today, 42.6% of Ukrainian companies do not apply international technical standards in principle. However, if we consider various areas of activity, then here we can identify our leaders. Thus, companies in the mining industry use international standards in their activities more often than others: in 60% of companies, the share of products manufactured using international technical standards is more than 50% (State Statistics Service of Ukraine, 2021).

The development of innovative activity is an increase in the innovative component of the national economy in accordance with industries and regions in order to ensure a balance from an innovative point of view of the sectors of the national economy and business entities.

The priorities of the state innovation policy, the stages of its implementation and the key directions for the development of innovation activity are directly determined by the needs of industrial production from the standpoint of its technological re-equipment. On the one hand, the availability of investment resources and, on the other hand, the creation of appropriate conditions for the development of innovation activity must be carried out for the absolute modernization of the technological base of the domestic economy and a significant increase in the level of competitiveness of products of enterprises of the machine-building complex in Ukraine.

Consider the specific measures proposed above for the development of innovative activity, which are advisable to be carried out at all levels of the national economy:

1. National level – strengthening integration processes in science to improve the quality of training specialists in promising high-tech areas.
2. Territorial level – coordination of state, regional and local executive authorities to develop an integrated approach to solving the problems of innovative development, the functioning of the innovation system and the effective conduct of the innovation policy of the state.

3. Industry level – active financing of fundamental scientific research in scientific and technical areas in priority sectors, it is advisable to implement it in the form of a single state program with clearly defined development vectors.

4. Micro level – ensuring the protection and use of intellectual property; formation of a unified system of training and retraining of personnel in the field of innovative entrepreneurship; improvement of the financial situation of scientists; involvement of young people in science.

Increasing investment activity is the provision of the required level and structure of capital investments in the country's economy and its individual sectors.

It should be noted that the constant increase in the number of problems of the machine-building complex leads to a decrease in its economic potential and increases the probability of failure of such enterprises. Opportunities for development of machine-building enterprises focused on the introduction of innovations and modernization of production are not realized due to lack of state support, lack of own funds, high cost of loans, and low investment attractiveness.

CONCLUSIONS
Improving state policy as the basis for ensuring the economic security of the machine-building complex in modern conditions is to develop specific areas that should be implemented centrally. The model of ensuring the economic security of the state based on the improvement of the structure of mechanical engineering will allow: firstly, to significantly simplify the process of state influence; secondly, to combine state regulation of mechanical engineering along with the preservation of the operation of market mechanisms; thirdly, to ensure the economic security of the state by influencing all spheres of the economy through its proportions to achieve sustainability.

The mechanism for ensuring the economic security of the state contains the following interrelated elements: a) the main goal of implementing this mechanism, which is to form a toolkit for ensuring the economic security of the state based on the improvement of mechanical engineering and the elimination of threats to the economic security of enterprises; b) strategic tasks of the state policy of the country; c) the principles of ensuring the economic security of mechanical engineering on the basis of the state policy of the country; d) object of influence at all its levels.

Promising vectors for increasing the level of economic security of the country's machine-building complex should contain mechanisms for regulating and supporting the modernization of the machine-building complex with an emphasis on improving the domestic economy (the implementation of active and versatile activities of the state and the effective activities of the relevant government bodies at different levels; achieving a high intensity of market self-regulation; formation of relations between engineering enterprises and the state.
Author Contributions: Conceptualization, OR; methodology, VK, OR; formal analysis, LF; investigation, MV; project administration, VK; data curation, OR; resources, LF.; supervision, VK; validation, MV; writing - original draft preparation, OR, LF; writing - review and editing, VK.

All authors have read and agreed to the published version of the manuscript.

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HYBRID APPLICATION OF DECISION TREES,
FUZZY LOGIC AND PRODUCTION RULES
FOR SUPPORTING INVESTMENT DECISION MAKING
(ON THE EXAMPLE OF AN OIL AND GAS PRODUCING COMPANY)

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ABSTRACT

During the last years, in most countries of Eastern Europe (and Ukraine in particular), even a simple reproduction of onshore hydrocarbon reserves was not ensured. Achieving the possible level of self-sufficiency in fuel and energy resources is a fundamental task of national economies, without which the successful implementation of economic, scientific, technical and social programs aimed at ensuring state independence and stability in Europe is impossible. However, the onshore oil and gas industry of the countries of Eastern Europe with significant volumes of unexplored oil and gas resources, with the cost of oil and gas several times lower than world prices, the presence of a significant number of oil and gas industries, drilling and geophysical enterprises, oil refineries, and an extensive network of oil and gas pipelines, highly qualified production teams allows, with their effective use, not only to stabilize, but also to significantly increase the production of oil, gas and condensate in the future.

An important reason for the drop in oil and gas production volumes is insufficient management efficiency of the cycle of parallel business processes of the oil and gas company: field exploration, their arrangement and development, production and sale of oil and gas. The solution is the application of effective economic-mathematical modeling at the strategic level of management and the use of knowledge-oriented decision-making support tools as an integral component of the complex information system of an oil and gas company.

Objectives: Therefore, the issues of: development of a complex system of economic and mathematical support for making fair and timely investment decisions at the macro level of an oil and gas production company, effective application of knowledge-oriented hybrid methods and technologies are becoming particularly relevant.

Methods/Approach: The paper uses a mathematical apparatus of the method of fuzzy logic, decision trees, data mining, knowledge-oriented decision support, theory of investment management and expertise in the field of management of oil&gas exploration and production local and international investment projects.

Results: first proposed the decision tree diagram of the effective investment management process of a oil and gas company in the search for hydrocarbons in modern economic conditions is proposed: received further development of the principles of hybrid application of intelligent technologies and knowledge-oriented basis and the problem of handling uncertainty while supporting investment decisions of an oil and gas company; first proposed two related prognostic models are proposed: the seismic impact model and a drilling impact model; first proposed two algorithms/models based on economic-mathematical modeling with elements of fuzzy knowledge to support decision-making of the tender&controlling committee of oil&gas production company.

Conclusions: Based on the foregoing, it can be concluded that it is efficient to use developed by authors hybrid, knowledge-oriented investment decision support for oil and gas production projects in Ukraine and other countries of Eastern Europe.

Keywords: investment project, oil&gas exploration and production, decision tree, production rules, fuzzy inference

JEL classification: G11, D81, D83, L71

Paper type: Research article.
INTRODUCTION

Over the past years, onshore hydrocarbon production in Eastern Europe has exceeded the growth of the resource base. The situation is complicated by the fact that with the constant deterioration of the structure of reserves at old deposits (Krasnyuk et al., 2022), the annual commissioning of new deposits with small reserves cannot compensate for the natural decline in production at old deposits. The only way to increase one's own production of gas and oil is a sharp increase in investments in the search for oil and gas, that is, geological exploration.

The process of making managerial decisions on investing in oil and gas exploration requires complex expert analysis, is associated with significant capital investments, has many branches of scenarios and nodes of decision-making, there is a need to take into account a huge amount of accumulated knowledge, existing open situations of uncertainty, specific industry risk and significant macroeconomic risks for the oil and gas industry of Eastern Europe.

It should be noted: methods of decision support have a significant prospect of application in current economic conditions (Krasnyuk et al., 2019) (liberalization of markets, globalization, increased competition, decrease in consumer loyalty, development of Internet and 24/7/365 digital technologies (Krasnyuk et al., 2022), Big Data, global and local crisis (Hraschenko et al., 2020) conditions etc). These methods should be based on a hybrid approach for using fuzzy logic, production rules decision trees etc). Since this approach is a powerful tool for solving complex specific problems of the national economies of Eastern European countries (in the oil&gas production industry).

Therefore, one of the necessary factors for increasing onshore hydrocarbon production in Eastern Europe and improving the efficiency, timeliness and fairness of the investment in exploration and production projects is the use of knowledge-oriented decision-making support tools.

METHODOLOGY

The paper uses a mathematical apparatus of the method of fuzzy logic, decision trees, data mining, knowledge-oriented decision support (Kulynych et al., 2022), theory of investment management and expertise in the field of management of oil&gas exploration and production local and international investment projects.

RESULTS

On the basis of the conducted research, performed Data Mining on industry Data Sets, industry experts interview and many years of experience of the authors, a decision tree diagram of the effective investment management process of a oil and gas company in the search for hydrocarbons in modern economic
conditions (significant receivables and payables in the industry, which hinders the effective current and strategic activities of oil and gas companies) is proposed (Appendix A).

Considering the above-mentioned problems, the need to forecast the impact of geological exploration on the future growth of reserves and the reverse task will naturally arise.

A study of the results of geological exploration projects in Ukraine over the last two decades was conducted and expert experience and Data Mining methods were used (Krasnyuk et al., 2018).

As a result, the following two related prognostic models are proposed: the seismic impact model and a drilling impact model (1) and (2):

\[
\begin{align*}
Z_{yp-3} &= 100 \times (S_{yp-8} \div 21) \\
S_{yp-8} &\leq FS(yp-8) \\
FS_{yp-8} &= S_{yp-8} \times Zs_{yp-8}
\end{align*}
\]

where:

- \( yp \) is the base year of the start of production, \( yp-3 \) is the year in which the reserves should be increased by the amount \( Z \), \( FS(yp-8) \) is a function of the available capacities from seismic research, \( S_{yp-8} \) - that is, in the \( yp-8th \) year it is necessary to perform \( S \) km of seismic exploration works in order to increase the reserves in the year \( yp-3 \) by \( Z \) million cubic meters of gas. \( FS_{yp-8} \) - necessary funding for seismic exploration in Euro in the \( yp-8th \) year in order to achieve an increase in reserves in the year \( yp-3 \) by \( Z \) million cubic meters of gas, the \( Zs_{yp-8} \) indicator is used for calculation - the price of 1 km of seismic works in thousand Euro in year \( yp-8 \).

\[
\begin{align*}
Z_{yp-3} &= 98,2 \times B_{yp-5} \\
V_{yp} &= Z_{yp-3} \times 0,05 \\
B_{yp-5} &\leq FB(yp-5) \\
FB_{yp-5} &= B_{yp-5} \times Zb_{yp-5}
\end{align*}
\]

where:

- \( yp \) - the year in which the production should reach the value of \( Vyp \), \( FB(y) \) - a function of the available drilling capacities (certain restrictions are imposed on the increase of drilling volumes: economic, technological, natural, organizational, etc.). \( Byp-5 \) - that is, in the \( yp-5th \) year, it is necessary to perform \( B \) meters of exploratory drilling in order to increase reserves in the year \( yp-3 \) by \( Z \) million cubic meters of gas and increase in production after another 3 years of \( Vyp \) million cubic meters of gas. \( FB_{yp-5} \) - necessary funding for drilling in Euro in the \( yp-5th \) year, the \( ZByp-5 \) indicator is used for calculation - the price of 1 linear meter of drilling works in thousand Euro’s.

Therefore, the mathematical models (Krasnyuk et al., 2021) mentioned above provide the necessary support when making strategic investment decisions of an oil and gas production company, make it possible to solve
predictive tasks of long-term planning with economic resources, technological and organizational production capacities for their optimal use and the fulfillment of the tasks set to increase the growth of reserves and production.

However, despite the above formalized economic and mathematical models, after analyzing the developed decision tree, its components and experts' knowledge, a proposal is put forward, a proposal was put forward regarding the need to use the fuzzy logic apparatus in the construction of fragments of a rule-oriented support system (Krasnyuk M., Krasnyuk S., 2021) for making a complex of investment decisions in the search for oil and gas deposits and their production.

The mechanism of logical conclusion of fuzzy rule-oriented decision support systems is based on a knowledge base formed by experts of an oil and gas company in the form of a set of predicate rules:

Rule 1: if \( x \) is \( A_1 \), then \( y \) is \( B_1 \),

Rule 2: if \( x \) is \( A_2 \), then \( y \) is \( B_2 \),

......

Rule \( n \): \( x \) is \( A_n \), then \( y \) is \( B_n \),

where:

\( x \) is an input variable; \( y \) - output variable; \( A \) and \( B \) are membership functions defined as \( x \) and \( y \).

There are several modifications of the fuzzy inference algorithm: Mandani, Tsukamoto (for monotonic resulting functions), Sugeno (used when the conclusion of the rule is a function of the input variables \( x \) and \( y \): \( z' = a'x + b'y \)), Larsen (the implication uses the multiplication operator), a simplified fuzzy inference algorithm.

Based on the conducted research and experiments by authors, it was concluded that the following combinations proved to be universal approximators and are recommended for use in the subject area under consideration:

- Gaussian membership function, composition using the product, implication according to the Larsen algorithm and the centroid defuzzification method;
- symmetric triangular membership functions, composition using the minimum operation and the Mamdani algorithm.

We present a simplified fragment of the designed fuzzy base of rules for supporting making investment decisions by an oil and gas production company, namely: a decision on the industrial development (development) of a field:

Rule 1: if the gas reserves in the field are small and the debit is small and the depth of the deposit is large and inflation is average, then further development is impractical (the payback period is very long);

Rule 2: if the gas reserves in the field are average and the average debit, depth is very large and inflation is low, then further development is appropriate (the payback period is average).

For this set of rules, it is appropriate to apply the Larsen algorithm.

Further in the explanation: \( x \), \( y \) are the names of the defined input variables in a specific decision-making situation regarding field development (field reserves, debit, deposit depth, etc.); \( z \) – the name of the output
variable (expediency of development (field development) based on the payback period); \( A1, A2, ..., B1, B2, ..., C1, C2 \ldots \) - heuristically found membership functions.

The possibility of using the fuzzy logic apparatus in fuzzy decision support systems is based on the following:

- a description of the conditions and decision method in a language that is close to natural;
- efficiency (related to universality) and is explained in particular by a theorem proved by Wang in 1992:
- for each material continuous function \( g \), which is defined on the compact \( U \), and for a random \( \varepsilon > 0 \), there exists a fuzzy system that forms the original function \( f(x) \) such that:
  \[
  \sup_{x \in U} \| g(x) - f(x) \| \leq \varepsilon
  \]
- universality: according to the Fuzzy Approximation Theorem, which was proved by B. Kosko in 1993, any mathematical system can be approximated by a system based on fuzzy logic;

Note that the disadvantages of the considered hybrid systems are the following: the ascending set of fuzzy rules is formulated by a human expert and may be incomplete or contain contradictions; the type and parameters of the membership function describing the input and output variables of the system are chosen subjectively and may not adequately reflect the surrounding reality.

One of the aspects of the above and an important scientific and practical task in current economic conditions (crisis in the field of energy supply and high prices for energy resources) is the holding of objective, effective and fair tenders and flexible controlling of tender contracts as one of the necessary factors for ensuring investment and logistics activity of oil&gas production companies in Eastern Europe.

Thus, the task is to determine the business plan that most fully meets the objectives of the tender, and to choose the optimal solution. This will ensure the maximization of relevant production indicators, compliance with environmental requirements, the use of modern technologies and the development of the region's infrastructure. Experience shows that making such a complex decision in most sectors of the national economy requires the use of qualitative elements - vague goals and limitations, which is an insufficiently resolved aspect of the problem area under consideration. That is, the task is a multicriteria optimization system in fuzzy circumstances.

Two algorithm’s/models developed by authors involves the hybrid application of knowledge-oriented technology and the theory of fuzzy sets to support the decision-making.

Therefore, the set task of the current research determines the selection of two levels of the problem:

- analysis and assessment of the proximity of the business plan to one global goal of the tender;
- the task of choosing from a set of business plans based on the criterion of proximity to the target area.

Therefore, the set task of the current research determines the selection of two levels of the task:

- analysis and assessment of the proximity of the business plan to one global goal of the tender;
- the task of choosing from a set of business plans based on the criterion of proximity to the target area.

Therefore, some basic designations are:

\( k \) - business plan number in the competition \( (k = 1, 2, ..., K) \);
$X = \{X_j\}, j = (1, J)$ - set of global target parameters, where each parameter $X_j$ is a linguistic variable.

For example, global evaluation parameters: $X_1$ - technological, $X_2$ - economic, $X_3$ – ecological.

Let the set of local ones be defined for the global parameter $X_j$:

$$X_j = \{X^j_i\}, i = (1, I)$$

(3)

For example, (for the oil and gas production industry):

$X^1_i$ – average volume of production;
$X^2_i$ – technological efficiency of the intensification method;
$X^3_i$ – economic efficiency of the recommended reservoir stimulation method;
$X^4_i$ – profit share for the benefit of the state;
$X^5_i$ – annual capital costs per 1,000 cubic meters of gas;
$X^6_i$ – total investments of the investor;
$X^7_i$ – general investments in environmental safety;
$X^8_i$ – investments in the system of transportation and preparation of hydrocarbons.

An important and necessary stage of methodological preparation for the activities of the tender&controlling committee as such is the expert determination of linguistic variables (parameters of business plan evaluation) of both levels and their functions of affiliation.

Also, a critical stage of methodological preparation is the use of expert information for the purpose of forming a knowledge base for determining global parameters through local ones. This expert engineering knowledge is conditionally permanent and changes little in tenders. For example, (for the oil and gas industry):

$\text{IF average volume of production} = \text{“high” AND technological efficiency of the intensification method} = \text{“high” THEN business plan} = \text{“high-tech”};$

$\text{IF the average production volume} = \text{“low” AND the technological efficiency of the intensification method} = \text{“low” THEN the business plan} = \text{“low technological”}.$

On the basis of the conducted research on the possibility of applying fuzzy logic in the problem formulation under consideration, we will use the elements of the fuzzy algorithm of Larsen's logical conclusion.

So, the first algorithm based on economic-mathematical modeling with elements of fuzzy knowledge to support decision-making of the tender and controlling committee was proposed for the first time:

Membership functions defined on local variables $X^j_i$.

1) The membership functions defined on the local variables $X^j_i$, are applied to the actual values of the local indicators from the business project.
where:
\[ t = [1, 2, ..., T] \] – is the term set of the linguistic variable \( X^i \);
\[ X^i \] – application of the membership function of the linguistic variable of the local parameter \( i \) of the global parameter \( j \) on the value \( t \) of the term set;
\[ y_0^{ijk} \] – input parameter of the \( i \)-th local \( j \)-th global indicator of the \( k \)-th business plan.

2) The calculated values are applied to the conclusions for each rule (which formalizes the extent to which the local parameters belong to the global parameter) and the coefficients are determined (an example for two rules):

\[
\alpha^{jk}_{\text{rule 1}} = X^{i=1,j,t=1}(y_o^{i=1,j,k}) \land X^{j,i=2,t=1}(y_o^{i=2,j,k}),
\]

\[
\alpha^{jk}_{\text{rule 2}} = X^{j,i=1,t=2}(y_o^{i=1,j,k}) \land X^{j,i=2,t=2}(y_o^{i=2,j,k}),
\]

where:
\( \alpha^{jk}_{\text{rule 1}} \) is the coefficient – the result of applying rule 1.

Further, using these coefficients and the composition operation for each rule, we obtain fuzzy sets:

\[
\alpha^{jk}_{\text{rule 1}} \times X^{j,i=1,t=1}(y_\Sigma^{jk}),
\]

\[
\alpha^{jk}_{\text{rule 2}} \times X^{j,i=2,t=2}(y_\Sigma^{jk}),
\]

where: \( y_\Sigma^{jk} \) is an argument – partial resulting fuzzy set of the global parameter \( j \), \( k \)-th business plan, the result of applying the rule;

3) All fuzzy subsets assigned to each output variable (in all rules) are combined together to form one fuzzy subset by the “Max Combination” method for each global linguistic parameter variable \( X^j \) of tender \( k \):

\[
X^{jk}(y_\Sigma^j) = (\alpha^{jk}_{\text{rule 2}} X^{j,i=2,t=2}(y_\Sigma^j)) \lor (\alpha^{jk}_{\text{rule 1}} \times X^{j,i=1,t=1}(y_\Sigma^j))
\]

(7)

4) Reduction to the clarity of the final membership functions of global parameters by the centroid method:

\[
\alpha^{jk}_{\Sigma} = \frac{\int X^{jk}(y_\Sigma^{jk})}{\int X^{jk}(y_\Sigma^j)},
\]

(8)
where:
\[ \alpha_{kj}^j \] - is a clear assessment of the global parameter \( j \) of the \( k \)-th business plan.

5) Since the importance of the global tender criteria is a variable value determined by the tender committee in each specific case, it is advisable to use the method of weighting coefficients to the obtained estimates of the global parameters in order to calculate the final assessment of the business plan:

\[
\alpha_{k}^j = \sum_{j=1}^{J} v^j \alpha_{kj}^j ,
\]

\[
\sum_{j=1}^{J} v^j = 1 ,
\]

(9)

where:
- \( \alpha_{k}^j \) is the clear weighted assessment of the optimality of the \( k \)-th business plan;
- \( v^j \) – is the weight of the global parameter \( j \) according to the terms of the tender.

The optimal of the proposed business plans is determined according to the following criterion:

\[
\max \alpha_{k}^j , \ k = 1,2,...,K .
\]

It is worth noting that the algorithm proposed above has received practical approval at enterprises of the oil and gas production industry of Ukraine.

The second fuzzy economic-mathematical model for effective investment management of an oil and gas company was also developed for the first time (using Data Science methods) and proposed by the authors - the cost of conducting exploration works is proposed to be determined according to the following formula:

\[
V_{seis} = V_{dog}^seis \left( 1 + 0.05 \times (KS_{prkilf} + KS_{prof}) \right) \times D_{qual}^{seis} ,
\]

(10)

where:
- \( V_{seis} \) - the cost of exploration works;
- \( V_{dog}^{seis} \) - basic cost of exploration works;
- \( KS_{prkilf} \) - tracking coefficient of the number of horizons;
- \( KS_{prof} \) - average coefficient of horizon tracking;
- \( D_{qual}^{seis} \) - fuzzy "penalty-incentive" coefficient of the quality of performed exploration works (Figure 1).
When calculating the fuzzy "penalty-incentive" coefficient for the quality of performed exploration works, fuzzy rules (Appendix B) are used, which operate on the following technological assessments: the probability of the existence of a hydrocarbon trap screen, compliance with the work deadline, and the quality of the geological task.

**DISCUSSION**

Advantages of using in the field of oil&gas investment projects the above proposed knowledge-oriented approach and models, based on fuzzy inference:

- different dimensions of global and local parameters do not play a role;
- the direction of optimization of the parameter (max or min) is not important, as the algorithm maximizes the degree of belonging to an exemplary fuzzy set.

Therefore, knowledge-oriented decision support systems should not be used if: the required result can be obtained in another (standard) way; an adequate and easily researched mathematical model has already been found for the object or process.

It is worth using the considered systems in the following cases: if expert knowledge can be formulated mainly in linguistic form; for complex processes in the absence of a simple mathematical model.

**CONCLUSION**

Therefore, in this paper there are following results: first proposed the decision tree diagram (appendix A) of the effective investment management process of a oil and gas company in the exploration for hydrocarbons in current economic and geological conditions; received further development of the principles of hybrid application of intelligent technologies (Krasnyuk et al., 2020) and knowledge-oriented basis and the problem of handling uncertainty while supporting investment decisions of an oil and gas company; first proposed two related prognostic models are proposed: the seismic impact model and a drilling impact model; first proposed...
two algorithms based on economic-mathematical modeling with elements of production rules to support decision-making of the tender and controlling committee of oil & gas production company.

On the basis of the above, it is possible to conclude about the need to use a fuzzy knowledge-oriented investment decision support for oil and gas production projects in Ukraine and other countries of Eastern Europe.

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All authors have read and agreed to the published version of the manuscript.

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**Conflict of interests**
The authors declare no conflict of interest.

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APPENDIX A

Figure 2, sheet 1. Decision tree of the oil and gas company’s investment management process in the search for hydrocarbons

Source: Developed by Author’s
Figure 2. Decision tree of the oil and gas company’s investment management process in the search for hydrocarbons

Source: Developed by Author’s
APPENDIX B

Fragment of production rules base for determining the "penalty-incentive" coefficient for the quality of oil and gas exploration

Rule 1: IF compliance with the deadline for oil and gas drilling works = timely execution of drilling works AND execution of the OG for oil and gas drilling works = excellent execution of the OG for drilling works THEN the "penalty-incentive" coefficient for the quality of the performed oil and gas drilling works = stimulation of the quality of performed drilling works.

Rule 2: IF meeting the deadline for oil and gas drilling works = timely execution of drilling works AND execution of the OG for oil and gas drilling works = excellent execution of OG for drilling works THEN the coefficient of "penalization-incentive" for the quality of the performed oil and gas drilling works = stimulation of the quality of performed drilling works.

Rule 3: IF compliance with the deadline for oil and gas drilling works = delay in drilling works AND execution of the GZ for oil and gas drilling works = satisfactory execution of the GZ for drilling works THEN the "penalty-incentive" coefficient for the quality of the performed oil and gas drilling works = penalty for insufficient quality of the performed drilling works.

Rule 4: IF compliance with the deadline for oil and gas drilling works = timely execution of drilling works AND execution of the OG for oil and gas drilling works = satisfactory execution of the OG for drilling work THEN the "penalty-incentive" coefficient for the quality of the performed oil and gas drilling work = penalty for insufficient quality of the performed drilling works.

Rule 5: IF compliance with the deadline for oil and gas drilling works = delay in drilling works AND execution of the GZ for oil and gas drilling works = excellent execution of the GZ for drilling works THEN the "penalty-incentive" coefficient for the quality of the completed oil and gas drilling works = base price of completed drilling works.

Rule 6: IF meeting the deadline for oil and gas drilling works = timely completion of drilling works AND execution of the OG for oil and gas drilling works = satisfactory execution of the OG for drilling works THEN the "penalty-incentive" coefficient for the quality of the performed oil and gas drilling works = base price of completed drilling works.

Rule 7: IF compliance with the deadline for oil and gas drilling works = timely completion of drilling works AND execution of the OG for oil and gas drilling work = good execution of the OG for drilling work THEN the "penalty-incentive" coefficient for the quality of the performed oil and gas drilling work = base price of completed drilling works.

Rule 8: IF compliance with the deadline for oil and gas drilling works = timely completion of drilling works AND execution of the OG for oil and gas drilling work = good execution of the OG for drilling work THEN the "penalty-incentive" coefficient for the quality of the performed oil and gas drilling works = base price of completed drilling works.

Rule 9: IF compliance with the deadline for oil and gas drilling works = delay in the execution of drilling works AND execution of the GZ for drilling works for oil and gas = good execution of the GZ for drilling works THEN the "penalty-incentive" coefficient for the quality of the completed oil and gas drilling works = base price of completed drilling works.
INITIAL STATES AND TRANSITIONAL EXPENSES IN PRODUCTION AND TRANSPORT SYSTEMS OPTIMIZATION

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ABSTRACT

The production and transport systems optimization models, as well as classical transport or distributive problems, mainly concentrate on finding the plan, optimum according to own characteristics, and don't take into account costs on system transition from its given (initial) state to defined as optimum. The neglect of such transitional expenses leads to certain losses of the corresponding models’ adequacy and to obtaining the absolutely-optimal solution, which is invariant to initial system state. In our paper we introduce and investigate the notion of relatively-optimal plans. The basic types of dependences of relatively-optimal plans and maximum achievable profit on the production and transport system initial state under the different functions of transitional expenses are determined. Corresponding computer calculations are also carried out and confirmed our theoretical results and conclusions. From the mathematical point of view, the accounting of initial states and the transitional expenses, on the one hand, complicates the corresponding models and computing processes, however on the other hand – does the models even more interesting, creates additional non-trivial effects.

Keywords: absolutely and relatively optimal plans, optimization models, profit.

JEL classification: C51, C61, O21

Paper type: Research article


INTRODUCTION

The researches of supply chains that are linking producers, transporters and consumers of products, forecasting of their expected behavior are becoming of particularly great value at the present stage.

However, in numerous literature on supply chains, which has been extensively published in recent years (Grazia Speranza, 2018; Zhang et al, 2020), in particular the integrated supply chains (Bowersox & Closs, 1996; Shapiro, 2000; Geunes et al, 2002; Poirier, 2003; Voss & Woodruff, 2003; Stadtler & Kilger, 2004; Simchi-Levi et al, 2004; Shaelaie et al, 2018; Guajardo et al, 2018) relevant issues are considered primarily on the descriptive level, the best case scenario with the simplest calculation formulas.

From our point of view, the study of supply chains systems with the use and development of relevant results in microeconomics (Varian, 1992; Jehle & Reny, 2000; Nicholson, 2000; Mathis & Koscianski, 2002)
and the theory of organization of industrial markets (Church & Ware, 2000; Pepall et al, 2001; Schmalensee & Willig, 2002; Carlton & Perloff, 2004) deserves serious attention.

The constructed production and transport systems optimization models (Kholodenko, 2020), as well as classical transport or distributive problems, mainly concentrate on finding the plan, optimum according to own characteristics, and don't take into account costs on system transition from its given (initial) state to defined as optimum.

The neglect of such transitional expenses leads to certain losses of the corresponding models’ adequacy and to obtaining the optimal solution, which is invariant to initial system state. However, this initial state, as a rule, explicitly or implicitly is accepted as identical (zero), i.e. the production and transport systems, which are projected are in question.

**METHODOLOGY**

However, in investment projection (Kong et al, 2022), which is similar in meaning, the criteria indicator NPV (net present value) is formed not only as the sum of the present value of future cash flows – but less initial investments, i.e. taking into account costs on transition from the zero-initial state to the state, which provides these inflows. Therefore, it is necessary to take into account not only the income (results) from the production and transport systems primary activity, but also the corresponding transitional expenses at their projection, not to mention the functioning production and transport systems optimization.

If for the production and transport systems under projection, transitional expenses depend only on the final state (at total – zero – initial state), then for production and transport systems, which are already functioning, transitional expenses depend both on final and on current (initial for optimization procedure) state, which can be different too. In this sense the production and transport system, which is being projected, can be considered as a partial case of the production and transport system, which is functioning, – at the fixed (zero) initial state.

The transitional expenses account reflects also the known lag of the production and transport (as well as any economic) system, and the impossibility of its quick and cheap transfer from one state to another one.

Therefore, the purpose of this article is clarification of influence of initial states and expenses of their transformation into production and transport systems optimal plans.

**RESULTS AND DISCUSSION**

The production and transport system activity optimization problem without the account of transitional expenses consists in finding of the extremum of some criterion function $F$, which depends on a possible system state $\mathbf{x}$ – at the corresponding restrictions on $\mathbf{x}$. The production and transport system profit
maximization $F$ as a function of production volume $x \geq 0$, which is produced in it and delivered to consumers, can be a simple and rather widespread example of such statement:

$$F(x) \rightarrow \max_{x \geq 0}$$

(1)

The profit function $F(x)$ is usually convex up, at first it grows (more and more slowly) with increase in production volume $x$, reaches its maximum at the point $x^*$, for which the condition $F'(x) = 0$ is fulfilled, then decreases (Figure 1) due to reduction of the specific income from production additional units’ realization and/or growth of specific costs on their production and transportation.

![Figure 1. Finding of the production and transport system optimum plan $x^*$, excluding transitional expenses](image)

Therefore, at optimization of production transport system excluding transitional expenses it is necessary first to find its optimum production volume $x^*$, and then to pass to it from any initial state somehow free of charge.

For accounting of the initial state (reached production and product transportation volume) of production and transport system $x_0$ and of transitional (to the desirable state) expenses it is necessary to construct the expenses function $Z(x,x_0)$ on change of production volume from the value $x_0$ into $x$. The basic type of such transitional expenses’ dependences at different options of the initial state $x_0$ is shown in Figure 2.

Note that transitional expenses $Z(x,x_0)$ grow with removal of the point $x$ from $x_0$, i.e. if $0 \leq x \leq x_0$, $Z(x,x_0)$ falls down on $x$, and if $x \geq x_0$ – it grows on $x$. $Z(x,x_0)$ grows quicker, than falls down, as the increase in production volume requires more significant expenses, than its reduction (but volume reduction is also connected with certain nonzero expenses). Function $Z(x,x_0)$ is convex down on $x$ at given $x_0$ due to the assumption that each subsequent deviation from $x_0$ requires higher expenses, than
previous one. With increase of $x_0$ the growth of $Z(x, x_0)$ if $x \geq x_0$ becomes faster, as at large initial production volumes their further increase demands more essential expenses.

![Graph](image)

**Figure 2.** The basic type of dependences of transitional expenses for change of production volumes of the production and transport system from $x_0^1$, $x_0^2$, $x_0^3$ into $x$

The identical character sections (descending or growing) of function $Z(x, x_0)$, corresponding to different $x_0$, don’t cross – otherwise transition to a certain state from the different initial states, which are on one side from it $x_0^1$, $x_0^2 \leq x$ or $x_0^1$, $x_0^2 \geq x$, could be carried out with identical expenses. Sections of different character are just crossed – if $x_0^1 < x < x_0^2$, the equality of transitional (from the different sides) expenses $Z(x, x_0) = Z(x, x_0)$ is possible.

Therefore, taking into account expenses $Z(x, x_0)$ on transition from the initial state $x_0$ to the desirable state $x$ the production and transport system optimization problem (1) turns into

$$F(x) - Z(x, x_0) \rightarrow \max_{x \in \mathbb{R}}$$

(2)

Respectively the optimality conditions turn as well: from $F'(x) = 0$ into $F'(x) = Z'(x, x_0)$.

Absolutely (without taking into account the transitional expenses) optimum plan

$$x^* = \underset{x \in \mathbb{R}}{\text{Argmax}} F(x)$$

turns into the set of relatively optimum plans

$$x^*(x_0) = \underset{x \in \mathbb{R}}{\text{Argmax}} \{F(x) - Z(x, x_0)\}$$

– the certain optimum (concerning this state) plan $x^*(x_0)$ will correspond to each initial state $x_0$.

Note the necessity of discounting of the transitional expenses $Z(x, x_0)$ with a certain decreasing coefficient for providing the comparison correctness (2), if the profit $F(x)$ at the state $x$ of production and transport system can be reached repeatedly (in several periods of time), and expenses on transition to this state are carried out once.
The problem (2) graphic solutions at different initial states $x_0^1 < x^*$ and $x_0^2 > x^*$ show (Figures 3, 4), that relatively optimum plans $x^*(x_0^1)$ and $x^*(x_0^2)$ (optimum concerning the states $x_0^1$ and $x_0^2$) differ from absolutely optimum plan $x^*$.

**Figure 3.** Finding of the optimum plan $x^*(x_0^1)$ of production and transport system with the initial state $x_0^1 < x^*$.

**Figure 4.** Finding of the optimum plan $x^*(x_0^2)$ of production and transport system with the initial state $x_0^2 > x^*$. 
It is obvious that at the successful initial state \( x_0 = x^* \) the solutions of the problem (1) (absolutely optimum plan) and (2) (relatively optimum plan) will coincide. If \( x_0^1 < x^*, \ x^*(x_0^1) \in [x_0^1, \ x^*], \) if \( x_0^2 > x^* \ x^*(x_0^2) \in [x^*, \ x_0^2], \) i.e. the relatively optimum plan is between the initial state and absolutely optimum plan.

The basic type of dependences of relatively optimum plans on the initial state of production and transport system at the transitional expenses different functions is shown in Figure 5. All functions \( x^*(x_0) \) are not decreasing and they are located only in two sectors. Depending on the ratio of profit functions \( F(x) \) characteristics and the transitional expenses \( Z(x, x_0) \) characteristics the functions \( x^*(x_0) \) can be convex up or down (with the inflection point \( x_0 = x^* \)), linear, partly linear.

![Figure 5. The basic type of dependences of relatively optimum plans on the production and transport system initial state at the transitional expenses different functions](image)

In limiting cases:

\[
Z(x, x_0) = 0 \Rightarrow x^*(x_0) = x^* \text{ (sectors horizontal border) – in the absence of transitional expenses the absolutely optimum plan } x^* \text{ is reached from any initial } x_0; \\
Z(x, x_0) = \infty \text{ (or } Z_x'(0,0) = F'_x(0) \Rightarrow x^*(x_0) = x_0 \text{ (sectors inclined border) – at infinitely high transitional expenses every initial state will be relatively optimum (concerning itself), any transitions become inexpedient.}
\]

It is easy to receive four basic transitional cases (Figure 5) on the simple numerical example. Let \( F(x) = 8 - (x - 3)^2, \) then \( F'(x) = 6 - 2x = 0, \ x^* = 3, \ F''(x) = -2 < 0, \) in the point \( x^* = 3 \) the maximum \( F(x) \) is reached.

We will define on the interval \( x_0 \in [0; 3] \) if \( x \geq x_0 \) functions of the transitional expenses.

\[
Z_1(x, x_0) = x - x_0, \ Z_1'(x) = 1 = F' = 6 - 2x, \text{ from here}
\]
At transitional expenses linear function $Z_1(x, x_0)$ the dependence of relatively optimum plans $x_1^*(x_0)$ is partly linear. To the certain limiting border $0 \leq x_0 \leq 2.5$ all initial states should be transferred in the relatively optimum plan $x_1^*(x_0) = 2.5$; after this limiting border (if $2.5 \leq x_0 \leq 3$) initial states become relatively optimum (the benefit in profit won’t compensate the loss on transitional expenses any longer) and don’t require any transformations.

$$x_1^*(x_0) = \begin{cases} 2.5, & 0 \leq x_0 \leq 2.5; \\ x_0, & 2.5 \leq x_0 \leq 3. \end{cases}$$

Coming back from the reviewed numerical example to the general case, we will define function

$$G(x_0) = \max_{x \in [0, x_0]} [F(x) - Z(x, x_0)]$$

as the maximum production and transport system profit, achievable from the initial point $x_0$, taking into account the transitional expenses. The basic type of such functions at different transitional expenses functions $Z(x, x_0)$ is shown in Figure 6.

**Figure 6.** The basic type of dependences of the maximum achievable production and transport system profit on its initial state at different transitional expenses functions
In limiting cases:

in the transitional expenses absence \( Z_1(x, x_0) = 0 \) \( G_1(x_0) = F(x^*) \), i.e. from any initial state \( x_0 \) the profit \( F(x^*) \) of the absolutely optimum plan \( x^* \) is reached;

at infinitely high transitional expenses \( Z_4(x, x_0) = \infty \) \( G_4(x_0) = F(x_0) \) – no changes of any initial state \( x_0 \) are inexpedient; you have to be satisfied with profit \( F(x_0) \) of this state.

For intermediate situations \( \forall x \neq x_0 \quad 0 < Z_2(x, x_0) < Z_3(x, x_0) < \infty \) inequalities \( \forall x_0 \ G_1(x_0) = F(x^*) \geq G_2(x_0) \geq G_3(x_0) \geq G_4(x_0) = F(x_0) \) are carried out. Increase of profit \( G_2(x_0) - F(x_0) \) or \( G_3(x_0) - F(x_0) \) is reached due to the transition possibility at finding \( G_2(x_0) \) or \( G_3(x_0) \) from the initial state \( x_0 \) to corresponding relatively optimum state \( x_2^*(x_0) \) or \( x_3^*(x_0) \), with the surplus compensation for expenses on this transition. Therefore functions \( G_2(x_0) \), \( G_3(x_0) \) become more flat in comparison with \( F(x_0) \), moreover their right (from \( x^* \)) part even more flat, than left one (Figure 6) as transitional expenses \( Z(x, x_0) \) at production volumes reduction are lower, than at their increase (Figure 2).

Only if \( x_0 = x^* \) the values of all functions \( G_i(x^*) = G_2(x^*) = G_3(x^*) = G_4(x^*) = F(x^*) \) coincide.

Note that unlike functions \( x^*(x_0) \), which could be convex both up and down (Figure 5), functions \( G(x_0) \) are convex up (Figure 6), but characteristics of this convexity up can be different (the options are shown by dotted lines in Figure 6) – depending on the transitional expenses’ functions \( Z(x, x_0) \) peculiarities. In particular, the function \( G(x_0) \) linearity sectors, corresponding to horizontal sectors of partly-linear function \( x^*(x_0) \) in Figure 5, are possible if transitional expenses function \( Z(x, x_0) \) is linear.

Now we will apply the stated general ideas to the classical transport problem

\[
f(x) = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} \cdot x_{ij} \rightarrow \min_{x_{ij}}
\]

(4)

\[
\sum_{j=1}^{n} x_{ij} = a_i, \ i = 1, \ldots, m
\]

(5)

\[
\sum_{i=1}^{m} x_{ij} = b_j, \ j = 1, \ldots, n
\]

(6)

\[
x_{ij} \geq 0, \ i = 1, \ldots, m, \ j = 1, \ldots, n
\]

(7)

where \( m \) – the number of producers in production and transport system,

\( n \) – the number of consumers,

\( a_i \) – the production volume of the producer \( i, \ i = 1, \ldots, m \),

\( b_j \) – the production necessity for the consumer \( j, \ j = 1, \ldots, n \),

\( c_{ij} \) – the specific costs on production transportation from the producer \( i \) to the consumer \( j \),

\( i = 1, \ldots, m, \ j = 1, \ldots, n \).
The initial state of such elementary production and transport system is denoted by \( x = \{ x_{ij} \} \), where \( i = 1, \ldots, m \) and \( j = 1, \ldots, n \), and \( x_{ij} \) is the product transportation volume from the producer \( i \) to the consumer \( j \). The initial state is denoted by \( x_0 = \{ x_{ij}^0 \} \).

Let \( Z(x, x_0) \) be the criterion function, taking into account expenses not only on transportation \( f(x) \), but also on transition from the initial state \( x_0 \) to the actual one \( x \). Then the criterion function (4) will turn into

\[
f(x) + Z(x, x_0) \rightarrow \min_{x \in \mathbb{R}^n} \tag{8}
\]

The transitional expenses function \( Z(x, x_0) \) can be determined in different ways. From the point of view of economic sense, the transitional expenses are connected, mainly, with the transportation’s organization on the new, earlier not involved destinations, and therefore it is possible to introduce the corresponding indicative variables

\[
\delta_{ij}(x_{ij}, x_{ij}^0) = \begin{cases} 1, & \text{if } x_{ij} > 0, \quad x_{ij}^0 = 0 \\ 0, & \text{if not} \end{cases}
\]

and expenses \( k_{ij} \) on the transportation’s organization from the producer \( i \) to the consumer \( j \). Then

\[
Z(x, x_0) = \sum_{i=1}^{m} \sum_{j=1}^{n} \delta_{ij}(x_{ij}, x_{ij}^0) \cdot k_{ij}. \tag{9}
\]

At such transitional expenses formation, the volume is not of the crucial importance, but the transportation fact is, and in the relatively optimum plan we should expect the minimum quantity of new transportations (busy cells) at their maximum possible volumes (since we transport somewhere – let’s do it at full scale). The criterion function (8) discontinuity due to the discontinuous component (9) is the drawback of this approach realization, which complicates the corresponding computing procedures.

From the mathematical point of view, it is expedient to determine the distance between the initial state \( x_0 \) and actual one \( x \) as distance between two points

\[
d(x, x_0) = \sqrt{\sum_{i=1}^{m} \sum_{j=1}^{n} (x_{ij} - x_{ij}^0)^2} \tag{10}
\]

then

\[
Z(x, x_0) = k \cdot d(x, x_0) \tag{11}
\]

where \( k \) – average specific transitional expenses.

Considering in (10) the expression \( s_{ij}(x_{ij}, x_{ij}^0) = \max\{x_{ij} - x_{ij}^0, 0\} \) instead of \( x_{ij} - x_{ij}^0 \) it is possible to take into account only the ways of transportation volumes growth in transitional expenses (11) formation.

Unlike the approach (9), here transitional expenses (11) and total expenses (8) become continuous; however, the particularities of function of distance between states (10) will lead to a large number of insignificant
transportations (the filled cells) that contradicts the problem economic sense at interpretation of the transitional expenses as expenses on the new transportation organization.

The transitional expenses determination as

\[ Z(x, x_0) = \sum_{i=1}^{m} \sum_{j=1}^{n} s_{ij}(x_{ij}, x_{ij}^0) \cdot k_{ij}. \]  \hspace{1cm} (12)

can be a certain compromise between economic (9) and mathematical (10) - (11) approaches.

In method (12) the transitional and total expenses continuity remains; the transitional expenses don’t depend on the new transportsations fact, as in (9), but on their volume; the difference in transportation volumes \( s_{ij}(x_{ij}, x_{ij}^0) \) has more transparent economic sense, than mathematical distance between states (10).

For simplicity instead of transportation organization specific expenses \( \{k_{ij}\} \), differentiated in the transportation destinations it is possible, as in (11), to consider the uniform average value \( k \). We will define the corresponding dependences taking into account these transitional expenses characteristic \( k \):

transitional expenses

\[ Z(x, x_0, k) = k \cdot \sum_{i=1}^{m} \sum_{j=1}^{n} s_{ij}(x_{ij}, x_{ij}^0), \]  \hspace{1cm} (13)

relatively optimum state

\[ x \cdot (x_0, k) = \text{Arg} \min_{x \in (5)-(7)} \{f(x) + Z(x, x_0, k)\}. \]  \hspace{1cm} (14)

the total expenses value (on transportsations and on transition to relatively optimum state), minimum achievable from the initial state.

\[ G(x_0, k) = \min_{x \in (5)-(7)} \{f(x) + Z(x, x_0, k)\} = f(x \cdot (x_0, k)) + Z(x \cdot (x_0, k), x_0, k). \]  \hspace{1cm} (15)

**Figure 7.** The basic type of dependences of total expenses \( G \), expenses on transportation \( f \) and on transition between states \( Z \) on the specific transitional expenses \( k \)
The basic type of dependences of this value and its components on the specific transitional expenses $k$ is shown in Figure 7.

At zero specific transitional expenses $k = 0$, it is possible to pass from any initial state $x_0$ to absolutely optimum state $x^*$ free of charge. At low specific transitional expenses $k \leq k_1(x_0)$ the transition is carried out all the same to the absolutely optimum state $x^*$ (expenses on transportation remain at the same level $f(x^*)$), however already with certain transitional expenses $Z(x^*, x_0, k)$ due to which – if transportation expenses are constant – total expenses $G(x_0, k)$ also grow.

At higher $k_1(x_0)$ specific transitional expenses $k$, the transition will be already carried out not to absolutely, but to relative optimum state $x^*(x_0, k)$, closer to the initial one, with higher expenses namely on transportation $f(x^*(x_0, k))$. At the same time the transitional expenses $Z(x^*(x_0, k), x_0, k)$ grow (but more and more slowly) to $k = k^*(x_0)$ (the transition itself from $x_0$ to $x^*(x_0, k)$ becomes shorter; however, the specific expenses on it grow rather quickly). Therefore, total expenses $G(x_0, k)$ also grow quickly enough on this interval.

If $k = k^*(x_0)$ the transitional expenses $Z(x^*(x_0, k), x_0, k)$ reach their maximum value (which is equal to the maximum distance between curves of transportation costs $f(x^*(x_0, k))$ and total expenses $G(x_0, k)$, then they begin to fall down (as approach rates of relatively optimum state $x^*(x_0, k)$ to the initial one $x_0$ already advance growth rates of the specific transitional expenses $k$). But expenses on transportation $f(x^*(x_0, k))$ due to fast approach of relatively optimum state $x^*(x_0, k)$ to initial one $x_0$ grow considerably faster, than transitional expenses $Z(x^*(x_0, k), x_0, k)$ fall down, and therefore total expenses $G(x_0, k)$ though slowly, but grow too.

Finally, if the specific transitional expenses $k \geq k_0(x_0)$ are very high, all possible transitions from the initial state $x_0$ are economically inexpedient, it becomes relatively optimum (concerning itself), therefore transitional expenses turn into zero, and total expenses $G(x_0, k)$ are equal to expenses on transportation $f(x_0)$ in the initial state.

Pay attention that the main values of the specific transitional expenses $k_1(x_0), k^*(x_0), k_0(x_0)$ depend on the initial state $x_0$.

Note also the basic (smoothed) type of the corresponding dependences is shown in Figure 7. While carrying out the computing experiments series by means of the option "Solver" of the MS Excel package on transport problems numerical examples the established general tendencies were observed rather accurately (especially concerning total expenses $G(x_0, k)$), however concerning components – i.e. costs on transportation and the transitional expenses – the certain not smooth effects (Figure 8), caused by specifics of linear programming problems conditions polyhedrons, took place.

Note the connection of the considered range of problems with monitoring, popular at the present stage, – tracking of systems functioning processes and accepted plans implementation. Therefore, at deviations identification it isn’t necessary to provide return to the earlier calculated optimum plan mechanically
(irrespective of the transitional expenses, i.e. at any cost), but to correct this optimum plan taking into account the transitional expenses, receiving the new desirable (relatively optimum) plan.

**Figure 8.** The empirical dependences example of total expenses \( G \), expenses on transportation \( f \) and on transition between states \( Z \) on the specific transitional expenses \( k \).

We will draw another parallel between the considered transitional expenses (on system transfer in the desirable state) and transportation costs on delivery (if \( x_0 < x^*(x_0) \)) or production pickup (if \( x_0 > x^*(x_0) \)). In economic literature both transfer costs, and transportation costs are often neglected for their allegedly insignificance, however actually they influence optimum plans significantly. It may be said as well that such expenses act as the certain smoothing factor, shifting relatively optimum state (which takes them into account) from absolutely optimum (at their absence) towards initial one.

The dependences of production and transport system income \( D(x) \) and total expenses \( Z(x) \), including production expenses \( Z_1(x) \) and transport expenses \( Z_2(x) \) on the production volume \( x \) are shown in Figure 9.

Without account (or at absence) of transportation costs, the production and transport system profit will be formed as \( F_1(x) = D(x) - Z_1(x) \), its maximum will be reached in the point \( x_1^* \), in which \( D'(x_1^*) = Z_1^*(x_1^*) \) (in Figure 9 tangents to curves \( D(x) \) and \( Z_1(x) \) in the point \( x_1^* \) are parallel).

Taking into account transportation costs, the profit can be found as \( F(x) = D(x) - Z(x) = D(x) - (Z_1(x) + Z_2(x)) = D(x) - Z_1(x) - Z_2(x) \), its maximum is reached in the
point $x_2^* < x_1^*$, in which $D'(x_2^*) = Z'(x_2^*)$ (in Figure 9 in the point $x_2^*$ tangents to curves $D(x)$ and $Z(x)$ are parallel).

It is clear, that $F(x_2^*) = D(x_2^*) - Z_1(x_2^*) - Z_2(x_2^*) < F(x_1^*) = D(x_1^*) - Z_1(x_1^*)$, i.e. in the point $x_2^*$, optimal at the transportation costs accounting, the production and transport system profit is reduced in comparison with the point $x_1^*$, which is ideally optimal (if there really weren't transportation costs).

However, $F(x_2^*) = D(x_2^*) - Z_1(x_2^*) - Z_2(x_2^*) > F(x_1^*) = D(x_1^*) - Z_1(x_1^*) - Z_2(x_1^*)$, i.e. in the real case (taking into account transportation costs) the profit in the point $x_2^*$ is higher, than in calculated for point $x_1^*$, which is the ideal case.

**Figure 9.** Production and transport system optimization at absence of transportation costs and at taking them into account

**CONCLUSIONS**

Therefore, it is better to correct the optimum plans taking into account transportation costs (than to insist on the optimums, received without their account) – then the real income will decrease in comparison with ideal one, but not so much as it would decrease in the transportation costs presence at orientation to the ideal optimum.

In the same way the transitional expenses accounting reduces the profit in comparison with a hypothetical case of their absence, however at their actual existence the profit in the respectively corrected relatively optimum state will be higher, than in absolutely optimum.

Thus, introduction of initial states and transitional expenses to the models of production and transport systems optimization will promote the increase of their adequacy, flexibility and adaptability that is especially actual in the economy market transformation conditions.
From the mathematical point of view, the accounting of initial states and the transitional expenses, on the one hand, complicates the corresponding models and computing processes, however on the other hand – does the models even more interesting, creates additional uncommon effects.

The further consideration of not only transitional expenses, but also of time for transition from the initial state to actual ones is supposed as namely the time factor is of crucial importance for the transport component of the production and transport systems (Voynarenko & Kholodenko, 2019).

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SECTORAL INNOVATION SYSTEM OF AGribusiness in Bulgaria – Main Challenges and Perspectives*

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ABSTRACT

This paper discusses the importance of public policy and current issues in the context of Agricultural Knowledge and Information System (AKIS) in Bulgaria. The goal is to outline the major challenges and perspectives as basis for analysis of the innovation potential within the sectoral innovation system of the agricultural sector in Bulgaria. Analysed is data about the major stakeholders, international and national programs supporting innovations in the sector, creation of new knowledge and technological solutions, scientific and research activity, state of transfer of technology in the context of agricultural ecosystem. A systematic approach with qualitative monitoring and quantitative assessment are applied for evaluation and definition of the types of effects in the innovation ecosystem. The results confirm, that despite the efforts and funds supporting AKIS, the public policy is not efficient, the stakeholder’s activity is limited, and the innovation and transfer of technology are not enough powerful to drive the economic growth and competitiveness in agriculture. The development of innovation potential should be based on the implementation of policies/addressing of measures that are relevant to the potential of the units of the innovation ecosystem and the priorities for their development.

Keywords: sectoral innovation system, science-business collaboration, innovation, potential, agriculture, Bulgaria

JEL classification: Q16, O30, O32
Paper type: Research article


INTRODUCTION

The developed research and innovation infrastructure, subject to regional characteristics is one of the key elements of the entrepreneurial and innovation ecosystem and a factor in turning the results of scientific activity into practical solutions to market needs. Research on entrepreneurial activity in the agricultural sector confirms the role of interaction and innovation networks (in the specific case in the form of value-added technological chains) for the success of newly created enterprises.

The EU policies in the field of the agricultural sector, the green transition and the digital transformation are the general framework for the development, the stimulation of the innovation potential and the increase of competitiveness in the agribusiness sector. Innovation and the transfer of technological knowledge are

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increasingly seen as drivers for the development of what are defined as low-tech or traditional sectors of the economy, including the agriculture. The existence of structural weaknesses - deficiencies of the institutional and infrastructural environment, along with the lack of capacity of the interested parties, can negatively affect the innovation processes. Addressing these challenges requires a systematic analysis of the sectoral innovation system and an assessment of the impact of the main factors and obstacles to innovation in agribusiness as a whole and as part of innovation ecosystems.

Innovation ecosystems include heterogeneous organizations that jointly grow in the creation of added value (Moore, Predators and prey: a new ecology of competition, 1993), (Moore, 1996) (Adner R., Kapoor R., 2010), (Thomas L., Autio E., 2014). Participants in the ecosystem can be with different status - objects, projects, clusters, organizations, with different ways and forms of financing, with different management models, network connectivity and built partnerships between them. Some of them can be purposefully created as a result of strategic policies, programs and interventions. The ecosystem is a dynamic structure, but at the same time all EU policies are supporting the active participants in the ecosystem.

The purpose of this article is to investigate the innovation potential of the sectoral innovation system of agribusiness as a basis for identification of major factors, responsible for innovation activity and the sources of competitive advantages at organizational, sectoral and national (regional) level. The focus will be placed on the role of different stakeholder groups and the interaction between them.

Innovation is one of the most recognizable factors of economic growth and competitiveness (Porter, 1990), (Fagerberg J., Srholec M., Verspagen, B., 2010). A number of studies from the end of the last century prove the need to apply the systematic approach in the analysis of the sources and factors of innovation activity substituting the prevalent linear model (Freeman, 1997), (Lundvall, 1992), (Nelson R. (Ed.), 1993), (OECD, 1996), (OECD, 1997). Further development of the theory of innovation systems leads to the identification of a number of features at the sectoral level that predetermine technological dynamics and are the basis for distinguishing high-tech from low-tech industries, sectors and activities (Pavitt, 1984), (Hatzichronoglou, 1997), (Carroll P., Pol E., Robertson P., 2000), (OECD, 1997), (OECD Reviews of Regional Innovation, 2011), (OECD Reviews of Regional Innovation, 2011).

Although the degree of penetration of innovations depends on such factors as farm size, benefits, productivity and business model, they will necessarily have to face the issues of climate change, new consumption patterns an at the same time meeting the needs (for food and resources) of the growing population (FAO, 2022). Innovations must be able to guarantee sustainable agriculture and the development of the agro-sector. On the other hand, innovation in the sector is moderate due to lack of investment and sufficient focus on sustainability (Berthet Elsa, Segrestin Blanche, Hickey Gordon, 2016). Additional constraint is the heritage of innovations in agriculture mainly focused on reducing labour and increasing production efficiency (Kirova, M., Montanari, F. et al., 2019).

The innovation system in the agricultural sector is highly dependent on a wide range of policies and in particular those, related to the creation and diffusion of innovations. The main challenges, on the one hand,
are the growing needs for growth in the efficiency and productivity of agricultural products with limited cultivated land, and on the other hand, responding to the priorities for sustainability, land protection, conservation of water resources and biodiversity. The OECD report (OECD, 2013) states that all reforms in the sector are primarily related to the improved integration of Agricultural Innovation Systems (AIS) into innovation systems, ongoing structural changes, governance structures, priority settings and funding mechanisms, the functioning of intellectual property markets and networking opportunities for partnership and cross-country cooperation. The public sector plays major role in the provision of knowledge infrastructure (databases, exchange platforms, centers of technology convergence) and financing scientific research in the agricultural sector. Key and decisive for sustainability is the integration, activity and participation of the various participants in the ecosystem, including of the private sector and public-private partnerships.

Figure 1. Agricultural innovation system


The key players in the innovation system in the agricultural sector (Tropical Agriculture Platform, 2016) are representatives of research and education, in the case of Bulgaria – mainly from the public sector; the bridging institutions – stakeholder platforms, agricultural extension organizations (public, private, civil), contractual agreements, contributing to the transfer, diffusion and application of innovations by business and
enterprises. The enabling environment is formed by innovation policies, investments and agricultural policies with the informal involvement of other stakeholders and their activity. The external environment at the macro level is constituted by science and technology policy, political system, science actors and technology from other sectors of the economy.

The development of research capacity within AIS is determined by the interaction and participation of individuals, organizations and an enabling institutional environment. This requires a focus on the level of support, synchronization of national and regional policies and interventions, both for existent and emerging initiatives e.g. individual initiatives (niche innovations), stimulating entrepreneurial discovery process (EDP), talent and creativity (Tropical Agriculture Platform, 2016). The understanding of the innovation system of the agricultural sector is a continuation of the concepts of Agricultural Knowledge System (AKS), Agricultural Knowledge and Information System (AKIS), Agricultural Innovation Systems (AIS), Learning innovation system for sustainable agriculture (Learning and Innovation Networks for Sustainable Agriculture, LINSA).

The present research is subordinated to the peculiarities of the sectoral innovation system of agribusiness. In fact, a number of scientific concepts in the field of innovation theory are launched for the first time and validated on the basis of data and analysis of the development of the agricultural sector. Such examples are the long economic cycles in the economy based on the accumulation and exploitation of new technological knowledge (Kondratieff, 1935) and the theory of innovation diffusion (Rogers E., 1995). Nowadays, in the conditions of exceptional growth opportunities arising from the dynamic development of new technologies and digital transformation processes on the one hand, and a number of global challenges on the other hand= The agribusiness is the intersection of significant changes in both political and regulatory mechanisms, changing business models and sources of entrepreneurial and innovation activity.

The linear model of the implementation of innovations by agricultural producers, as the final users of innovations, is responsible for the rapid industrialization and productivity in the agricultural sector, but it is strongly criticized for its negative environmental and social effects (Vanloqueren G., Baret P.V., 2017), (Knickel, K., Brunori, G., Rand, S., Proost, J., 2009). Among the main criticisms is the fact that the linear model excludes interaction and partnership between participants in the ecosystem and the possibility of generating innovations from other participants - part of the circular and bioeconomy (Berthet Elsa, Segrestin Blanche, Hickey Gordon , 2016), (Berthet Elsa, Hickey Gordon, Klerkx Laurens, 2018).


The model of open innovations defends the thesis that knowledge flows occur both from inside and outside enterprises, moving inside and outside them within various forms of interaction and partner networks,
including alliances, consortia, ecosystems, platforms, societies, etc. (Chesbrough H. W., 2003), (Vanhaverbeke, 2006), (Adner R., Kapoor R., 2010).

The EU policies for smart, sustainable and "green" growth require research on sustainability, environmental protection, biodiversity and, on the other hand, input resources, the quality and safe production with high added value. The application of innovations, the period of operation and the size of the farm are among the leading factors of competitiveness in the agricultural sector (Panteleeva I., Varamezov L., Kostadinova N., 2018). Other authors identify as the most limiting factors for innovations in agriculture the cost of investment for innovation and the lack of information about possible innovations (Harizanova-Bartos H, Dimitrova A., 2018). Research dedicated to logistics and added value chains in agribusiness (Linkova M., Lazarova E., 2021) finds effective utilization of available resources and generation of added value and a prerequisite for innovation and transfer of technological knowledge.

The innovations on a sectoral basis demand to go beyond the standard internationally accepted system of indicators for measuring innovation as a linear process and the result of scientific research only. The shift in emphasis to sectoral innovation systems and technology chains is more closely related to the concept of open innovation. This is why, besides the usual indicators, measuring intensity of scientific research activity, we attempt to define the factors-specific drivers of innovation activity on a sectoral basis and to characterize the mechanisms for implementation of innovation and the various forms of manifestation of the expected effect.

The current research aims to:
- Define the importance of the agricultural sector as a factor for increasing the competitiveness and growth of the Bulgarian economy;
- Outline the boundaries of the sectoral innovation ecosystem of agribusiness in Bulgaria on the basis of formal and informal interactions and knowledge flows;
- Evaluate the innovation potential of the agro-sector in Bulgaria to create and apply new knowledge in national and international context.

**ECONOMIC IMPORTANCE OF THE AGRICULTURAL SECTOR IN BULGARIA**

The agricultural sector has a serious potential to 1) support development of a competitive economy based on the principles of sustainable development and green innovations; 2) create of solutions of social, economic and environmental problems of modern society; 3) meet growing requirements regarding food safety and quality; 4) address policies for balanced development of rural areas.

The agricultural sector is very sensitive in terms of political decision-making and inhomogeneous in terms of activities, applied technologies and final products. The approach to its research from the positions of sectoral innovation systems makes an attempt to examine it in its entirety, subject to the high level of interdependence between the individual stages of the innovation process.

In Bulgarian agriculture, the sub-sectors with the greatest economic importance are plant breeding in the production of grain and oil crops, fruits and vegetables, and animal breeding (the production of milk, pork,
poultry, beef and lamb meat and eggs). The data for 2021 show that the gross value added (GVA) of the agricultural sector is under BGN 5 million, forming 4.3% of the total GVA for the country. There is a sustainable upward growth trend since 2018, achieving growth in real terms of 6.1% for 2021. The dynamics of GVA from agriculture shows that in 14 years it has grown from BGN 2,954 million (2007) to only BGN 4,950 million (2021), despite huge subsidies and financial intervention for increasing the sector's competitiveness. The public subsidies in the sector do not have the expected positive influence on the gross value added (GVA) produced by the agriculture. Regardless of the growth in the absolute amount of GDP, it is insignificant compared to the dynamics of GDP from other sectors of the country's economy (See Figure 2).

![Figure 2. Gross value added of the agricultural sector at current prices, in million BGN](source: NSI)

Investments in the sector are between 1.3-1.5 billion BGN per year and are mainly in modernization of farms and support to meet food and feed safety standards; environmental protection; animal welfare; renovation of equipment and the introduction of new technologies; modernization in the processing industry, etc. Officially, the number of employed are 193,600 people or 6.3% of the total number of employed in the country. Bulgaria is the leader in the registered growth in labour productivity, and according to Eurostat data, there is a growth of 32.9% compared to 2020 with an average of 1.5% for the EU-27. The increase in productivity is mainly due to changes in production values and higher prices of raw materials, while maintaining the volume of agricultural labour.

The total value of agricultural exports for 2021 is over 6 billion euros, equivalent to 25.8% increase compared to the previous year. The increase in imports was weaker (10.5%), with the positive balance growing twice on an annual basis and reaching 1.6 billion euros. In 2021, the agricultural sector formed 14.1% of the
country's total trade for the year, including 17.3% of total exports and 11.3% of total imports. In 2021, trade with the EU-27 represents 62.4% of Bulgaria's total agricultural exports and 75.9% of total agricultural imports. The leading place in the export of Bulgarian agricultural goods is occupied by Greece and Romania (23.7% of the total export for 2021), followed by Spain (7.3%), Germany (6.2%), Italy (5.7%), The Netherlands (4.9%). In exports to third countries, with a share of 29.7% are countries like Turkey, China, the USA, Korea and Great Britain. With potential and huge growth compared to the previous 2020 are countries such as Vietnam (growth of 1969.1%), Korea (growth of 754.7%) and Pakistan (+337.5%). The war in Ukraine and political decisions related to grain production and trade are influencing the agriculture market. According to preliminary data of the Ministry of Agriculture, in 2022 there is an increase in the export of the main grain and oil crops.

Foreign direct investments (FDI) in the sector "Agriculture, forestry and fisheries" for the period 2008-2020 marked stable decline since 2014 (see Table 1)

<table>
<thead>
<tr>
<th>Table 1 Foreign direct investments in non-financial enterprises by economic activity groping, mln. Euro</th>
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<tr>
<td>--------</td>
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<tr>
<td>Total</td>
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<td>Agricul</td>
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<td>and</td>
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<td>fishing</td>
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<td>Share%</td>
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</table>

Source: NSI

Figure 3. Distribution of agricultural holdings by region, 2019

Source: Ministry of Agriculture, Bulgaria
There is permanent trend of reducing the number of farmers and from 493,100 in 2007 achieving 132,400 in 2020, cutting the numbers of smaller farms (Ministry of Agriculture, 2019). The distribution of agricultural holdings on the territory of the country is uneven, with the exception of districts of Plovdiv and Blagoevgrad. According to data from the last census (2020) the utilised agricultural area (UAA) in Bulgaria is 3957 thousand ha, which is an increase of 9% compared to 2010 and 36% increase compared to 2003. The family workforce and the permanently employed are 292 thousand people. The relative share of the family's unpaid hand is 79%. According to NSI data, there are 193.6 thousand people employed in the "Agriculture, Forestry and Fisheries" sector before 2021, which is 6.3% of those employed in all economic sectors.

![Figure 4. Employed in the "Agriculture, Forestry and Fisheries" sector](Source: NSI)

According to data from the Ministry of Agriculture (Ministry of Agriculture, 2019), the average values and distribution by size of agriculture holdings, UAA in Bulgaria for 2020 is presented as follows:

<table>
<thead>
<tr>
<th>Table 2 Distribution of agricultural holdings, by number, size and UAA</th>
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<tbody>
<tr>
<td>Area, ha</td>
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<tr>
<td>Very small agricultural holdings</td>
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<tr>
<td>Small agricultural holdings</td>
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<tr>
<td>Medium agricultural holdings</td>
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<tr>
<td>Large agricultural holdings</td>
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<tr>
<td>Very large agricultural holdings</td>
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</tbody>
</table>

*Source: Ministry of Agriculture, Bulgaria*
The registered organizations of fruit and vegetable producers and their associations are 17, the organizations of milk producers, associations of producers’ organizations, organizations for milk and dairy are 3 in total, the organizations of producers of agricultural products, associations of organizations of producers groups of producers in the Republic of Bulgaria are 25. As conclusions, there is limited number of associations in the agriculture.

Despite the changes that have occurred in the direction of restructuring, industrialization, specialization, agriculture is dominated by individual or family small farms that are relatively independent, and thus remain difficult to influence by dynamically changing technological factors.

The analysis of the support of agricultural holdings with direct payments between 2007-2013 and 2014-2020 (Koteva N., Ivanov B., 2020) show that 1/3 of the agricultural holdings were financially supported. There is an uneven distribution between the beneficiaries in favour of the larger agricultural holdings, which has been preserved over the years. Direct payments in the researched period grew nearly 4.7 times (from 166.4 million in 2008 to 777.4 million before 2020), becoming an important tool and income for farmers, but without significant results.

A study funded by the Bulgarian National Science Fund to evaluate the competitiveness of farmers in Bulgaria shows that more than a third of all farms have a low level of competitiveness. Factors responsible for this include low productivity, profitability, financial security and adaptability to changes in the natural environment (Bashev H, Koteva N., 2021).

POLICIES AND STRATEGIES IN THE FIELD AT INTERNATIONAL, EUROPEAN AND NATIONAL LEVEL TO SUPPORT INNOVATION IN THE AGRICULTURAL SECTOR

The most important strategic document at international level is the Program for Sustainable Development until 2030 and the set of seventeen Sustainable Development Goals (SDGs), which at the national level is deployed in the National Program Bulgaria 2030.

The Food and Agriculture Organization of the United Nations (FAO) adopted the FAO Science and Innovation Strategy (FAO, 2022) which outlines the critical contribution of science and innovation to the transformation of food systems. It highlights the role of science and innovation as crucial to finding solutions to climate challenges, managing knowledge and spreading innovation, by promoting and adapting to local needs and reaching the smallest farmers and producers.

At the EU level, the strategic framework and the main instruments aimed at scientific research and innovation are part of the pan-European policy, in fulfilment of the UN Sustainable Development Goals 2030, the EC priorities (2019-2024), the Recovery and Development Plan, the European Green Deal, Europe fit for the digital age, an Economy that works for the people, the Strategic Plan 2020-2024 for Research and Innovation strategy and others. All of them emphasize the importance of innovation and scientific research as major drivers, empowering growth, smart specialization and competitiveness. The so-called innovation
principle, including all new EU policies or regulations support innovation. Directly related to R&D and innovation are also the European Research Area (ERA), the Pact for Research and Innovation in Europe and the Horizon Europe programme.

The Strategic Plan (2021-2024) for the Horizon Europe program includes four key strategic directions supported by 15 impact areas structured in 6 clusters that make up the second pillar of Horizon Europe, Global Challenges and European Industrial Competitiveness. Among the co-financed partnerships of particular interest to the agricultural sector are:

- European Clean Energy Transition Partnership
- European partnership to accelerate the transition of agricultural systems:
- European Partnership for Animal Health and Welfare
- European Data Farming Partnership
- European Partnership to Save Biodiversity to Protect Life on Earth
- European partnership for a climate-neutral, sustainable and productive blue economy, etc.

Europe's strategy for international cooperation in a changing world is a new EC strategy outlining the priorities for strengthening the EU's leading role in supporting multilateral research and innovation partnerships to deliver new solutions to environmental challenges, digital technologies, healthcare and innovation.

The new European Research and Innovation Area aims to build a common science and technology area for the EU, the creation of a single market for research and innovation that promotes the free movement of researchers, scientific knowledge and innovation and stimulates the creation of a more competitive European industry. This includes restructuring the European research environment to strengthen cross-border cooperation, continent-wide competition, achieving "critical mass" and cooperation, and improving national research policies and systems. The European Strategic Forum on Research Infrastructures (ESFRI) has developed plans for 55 European research infrastructures in all fields of science, 37 of which have already been implemented and have mobilized investments of €20 billion. Since 2004, national investments in joint research programs amounting to more than 7 billion euros have been made. The European Open Science Cloud, the Data Exchange Platform, the EURAXESS Platform (to support the mobility and career development of researchers) are launched.

The European Institute of Innovation & Technology (EIT) supports businesses, educational and research institutions to work together to create an environment conducive to innovation and entrepreneurship in Europe. The institute enhances Europe's innovation capacity and its ability to compete with foreign partners and thereby create jobs and wealth. It brings together three key drivers of innovation – business, education and research – to help form dynamic, multi-stakeholder partnerships known as Knowledge and Innovation Communities. Of particular interest is the community for innovations in the food system, in which Bulgaria also participates. EIT Food is the leading European food innovation initiative working for a more sustainable, healthy and reliable food system. It is a pan-European consortium that focuses on entrepreneurship and
innovation in the food sector. The members of the EIT Food community are leading organizations in the international food field: more than 50 partners from companies, research centres and universities in 13 countries.

The Access to Research for Development and Innovation (ARDI) program of the World Intellectual Property Organization (WIPO) aims to increase the availability of scientific and technical information in developing countries. The database is grouped into several main areas of science: HINARI (medical literature), AGORA (food and agriculture), GOALI (law and social sciences), OARE (environment).

The leading strategic document in the field of agriculture is the Common Agricultural Policy (CAP) aimed at supporting farmers and increasing agricultural productivity to ensure stable food supplies at affordable prices; protection of farmers' living standards; help to address climate change and sustainable management of natural resources; care for the state of rural areas and landscapes across the EU; maintaining the viability of the rural economy by promoting employment in agriculture, food processing and related sectors.

The New Common Agricultural Policy: 2023-2027 paves the way for a fairer, greener and results-oriented CAP. Among the main goals are, fair incomes for farmers; increasing competitiveness; improving the position of farmers in the food supply chain; action to combat climate change; as a serious emphasis is placed on care for the environment; landscape and biodiversity protection; supporting generational change; viable rural areas; preservation of food quality and health; stimulating knowledge and innovation.

During the period 2021-2027, within the framework of the CAP, 387 billion euros have been allocated through the two funds - the European Agricultural Guarantee Fund (EAGF) (direct aid and financing of market measures) and the European Agricultural Fund for Rural Development (EAFRD) (financing for rural development). More €8 billion from the EU’s Next Generation are planned to help rural areas make the structural changes needed to achieve the goals of the European Green Deal and the digital transition.

The new emphases are on knowledge, research and innovation for a smart and sustainable agricultural sector. Within the framework of the "Horizon Europe" program, 10 billion euros have been earmarked for projects related to food, agriculture, rural development and the bioeconomy. The new CAP strengthens the position of farmers in the supply chain. The Farm to Fork strategy is based on the European Green Deal, which aims to make food systems fair, healthy and environmentally friendly.

The long-term vision for EU rural areas 2040 aims to make rural areas stronger, connected, resilient and prosperous by harnessing the emerging opportunities resulting from the EU's environmental and digital transition and the lessons learned from the COVID-19 pandemic such as the quality of life in rural areas has increased, balanced territorial development has been achieved and economic growth has been stimulated. A Pact for Rural Areas and an Action Plan for Promoting Sustainable, Coherent and Integrated Development of Rural Areas are to be adopted. Scientific research and innovation as well as the rural revitalization platform are essential tools to achieve the "stronger" part, to "connectivity" digitization and sustainable multimodal rural mobility, and to sustainability - the fight against climate change, carbon farming, deal for soil, social
sustainability and women in rural areas, and to "prosperous" - entrepreneurship and social economy in rural areas.

At the national level, within the National Development Program Bulgaria 2030 agriculture takes its place within the framework of priority 6 Sustainable agriculture. The focus is on the *structural and sectoral balance* of agriculture and the acceleration of restructuring processes in the sector - strengthening small family farms, achieving an appropriate balance between crop production and livestock production and their sub-sectors, the entry of young people into agricultural business. The areas of impact are crop production, livestock production, economic potential of small farms, age structure of farmers, areas with natural or other limitations.

In second place are *incomes of agricultural producers*, support for the sustainability of production structures and an increase in their market power and competitiveness. It relies on mechanisms for direct support and risk management in agriculture (adverse climatic events, spread of diseases and enemies of plants and animals, prevention and reduction of losses).

In third place is the *competitiveness of agriculture* based on the increased efficiency of production, the accelerated entry of innovations, the growth of productivity, the improvement of marketing and the market organization of supply, finding access to new markets. Investments are planned for modernization, *innovation and digital technologies* in agricultural holdings. Interventions aimed at implementing innovations and digital solutions, including those related to precision agriculture, will have a special focus. It is planned to build a complete electronic information system in agriculture, which will allow the digitalization of information flows from and for the implementation of administrative activities and, digitalization of the services provided to farmers. Strengthening the market positions of farmers will contribute to a fairer distribution of the added value created along the food chain by promoting the association of agricultural producers, stimulating *vertical integration between producers and processors of agricultural products*, shortening food supply chains. Qualification and knowledge of agricultural producers and in particular stimulating the *transfer of knowledge and the provision of information concerning scientific research and innovation* in the field of agriculture, including the bioeconomy.

In the fourth place, the *role of the agricultural sector for environmental protection* is defined, by encouraging the application of environmentally friendly practices in agricultural production, with a contribution to the protection of water, soil, air and biodiversity. The focus is on agro-ecological commitments and the implementation of agricultural practices aimed at adapting and strengthening ecosystems dependent on agriculture. Special attention is given to promoting organic production and increasing the production and consumption of clean and high quality food. In connection with the adaptation of climate changes, investments in irrigated agriculture and hydromelioration are planned for the improvement and sparing use of water resources.

In fifth place is the support of fisheries and aquaculture in order to reach the European level on the basis of improved competitiveness and sustainability.
Within the framework of the National Plan for Recovery and Sustainability under the priority Green Bulgaria - Sustainable Agriculture is set. Reforms related to updating the strategic framework of the agrarian sector in the context of the countries commitments resulting from the SDGs and the Green Deal are foreseen. Farmers should rapidly change their production methods, use nature-friendly, technological and digital solutions to ensure better climate and environmental results.

In the Innovation Strategy for Intelligent Specialization of the Republic of Bulgaria (2014-2020) as well as in the draft Innovation Strategy for Intelligent Specialization 2021-2027 of the Republic of Bulgaria, the thematic area "Industry for healthy living, bioeconomy and biotechnology" is preserved. "The vision for the development of the thematic area envisages that by 2030, Bulgaria will establish itself as a producer of bioproducts - food, cosmetics, medicines, produced from Bulgarian raw materials; to build an image of a destination offering safe high-quality medical, healing and rehabilitation services, including with high-tech products and devices using nanotechnology and meeting the highest global standards". The analysis for the period 2014-2020 shows that this thematic area is in second place (25.3%) of funds used and approved projects (60 projects). With the highest interest in "methods for clean production, storage, processing and reaching the end user of specific Bulgarian ingredients, means and products", and with the lowest "production of specialized foods and drinks (infant and children's, "cosmic" foods)". By types of innovations in the thematic area "Industry for healthy living, bioeconomy and biotechnologies are supported (Innovation Strategy for Intelligent Specialization (ISIS) Project, 2021-2027 of the Republic of Bulgaria, 2022):

- Supported enterprises that introduced new products for the enterprise - 21 in total
- Supported enterprises that introduced new products to the market - 24 in total
- Supported enterprises through Sofia Tech Park - 4 in total

The implemented procedures under Operational Programme “Science and Education for Smart Growth“ with a total value of 219.9 million euros display that 63.7 million euros or 28.97% of the total amount have been paid in the thematic area "Industry for a healthy life, bioeconomy and biotechnologies". The low degree of cooperation between enterprises and scientific structures and organizations is indicated among the barriers to the diffusion of innovations in the interim assessment of ISIS 2014-2020.

The national strategy for small and medium-sized enterprises in the part Measure 1.5 Support for crafts, entrepreneurship in rural areas and creative industries, incl. at the regional level (Action 3). By measure 4.1 Promoting the digitization of SMEs, support is provided for SMEs through the introduction of digital technologies and software products for automation and robotization of production processes, communication and distribution technologies, etc. in agriculture.

The update of the National Action Program to contribute to the implementation of the objectives of the "Farm to Fork" Strategy until 2030 is aimed at promoting green investments, sustainable management of natural resources (water, soil, air), adaptation to climate change and mitigation of their consequences. The
program will outline a framework for the management and protection of the environment and natural resources in the field of agriculture. It includes a complex of tools and activities until 2030 related to the implementation of specific goals and commitments such as preparing an analysis of the opportunities for low-carbon agriculture and more efficient use of natural resources; increasing the awareness and knowledge of agricultural producers about the benefits and ways of introducing ecological practices and solutions based on nature, opportunities to apply the principles of the circular economy; investments related to the protection of environmental components, as well as the introduction of innovative production and digital technologies in work processes; investments in facilities and equipment to overcome the consequences of climate change for the agricultural sector, etc. Investments are planned for:

- Fund for promoting the technological and ecological transition of agriculture, provide supports to farmers for the realization of targeted investments, for the purchase of tangible and intangible assets for the implementation of activities ensuring the protection of environmental components and mitigating the consequences of climate changes introducing innovative production and digital technologies, technologies for production and organization in agriculture, to automate work processes, to shorten supply chains and protect genetic resources. The total planned resource is BGN 962.2 million (BGN 437.4 million at the expense of the Recovery and Sustainability Mechanism and BGN 524.9 million in national co-financing, including BGN 437.4 million in private co-financing) with an implementation period of 2022-2025.

- Digitization of processes from the farm to the table. It is planned to build a comprehensive electronic information system in agriculture, through which to achieve: digitalization of information flows from and for the implementation of administrative activities; digitalization of services provided to farmers, their centralization and their use by businesses in the course of fulfilling obligations and requirements depending on the type of agricultural activity; integration of the administration's information systems and creation of an opportunity for automated data exchange between the administration and farmers. The total planned resource is BGN 23.9 million (BGN 19.9 million at the expense of the Recovery and Sustainability Mechanism and BGN 3.9 million national co-financing) with an implementation period of 2022-2025.

The Strategy "Digital Transformation of Bulgaria for the period 2020-2030", in the part of the Strategy for Digitization of Agriculture and Rural Areas of the Republic of Bulgaria, foresees the following areas of activity to develop the potential of the Bulgarian agrarian economy: building and developing an appropriate digital infrastructure for communication and connectivity; investment in modernization and technologies for precision agriculture; development of digital networks and use of software applications in business management and decision-making; awareness, training and advisory services for the development of digital skills and qualifications, research and innovation, partnership for the exchange and transfer of innovations, development of infrastructure for experimentation and access to it. The main goal of the digitization of Bulgarian agriculture and the related agricultural business is to turn it into a highly technological, sustainable,
highly productive and attractive sphere of the Bulgarian economy, which not only improves the living conditions of farmers, but also of rural areas such as whole.

Agriculture and rural areas can benefit in larger degree of new technologies and knowledge, without in any way jeopardizing the functionality of farmers. Therefore, digitization is set as a major cross-sectoral priority in the European Commission’s Proposal for a Regulation on Strategic Plans under the Common Agricultural Policy (CAP). The main institution at European level responsible for digitizing agriculture and promoting innovation is the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI).

Within the framework of the Strategy for Digitization of Agriculture and Rural Areas of the Republic of Bulgaria, the aim is the accelerated digitization of Bulgarian agriculture and rural areas, including the public administration, optimization of production processes, increase of farmers’ incomes and yields, achievement of sustainable bio - industry, maintenance of food safety in conditions of increased industrialization and new unproven technologies, a drastic increase in competitiveness and increased demand for Bulgarian products on the single European and world markets. The specific objectives, outputs, effects and areas of interaction are summarized as follows:

Table 3. Objectives, results, effects, areas of impact of the Strategy for digitization of agriculture and rural areas in the Republic of Bulgaria

<table>
<thead>
<tr>
<th>Strategic goals of digitization</th>
<th>Specific goals in agriculture</th>
<th>Specific results of digitization</th>
<th>Expected effects</th>
<th>Areas of impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Increasing the productivity and sustainability of agricultural production; 2. Improving people's health through the production of quality food; 3. Protecting the environment and addressing the challenges of climate change; 4. Increasing/expanding the presence of Bulgarian products on the Single European Market and on world markets; 5. Stimulating interest and attracting young people to develop agriculture;</td>
<td>1. Increase in income of farmers; 2. Reduction of production costs; 3. Improving the traceability and quality of the manufactured products in view of the demand and requirements of the market/consumers; 4. New funding opportunities.</td>
<td>1. Improved access to information; 2. Improved access to counseling service; 3. Improved access to markets and distribution of production; 4. Improved access to financing and reduced dependence on CAP subsidies; 5. Significant acceleration of administrative activity and reduction of the administrative burden;</td>
<td>1. Higher selling prices for farmers' produce and production in volume to satisfy demand; 2. Better risk management, including the risk of natural disasters; 3. Higher yields; 4. Reduction of the harmful effects of agriculture on the environment; 5. Reduction of intermediaries in the agri-food chain and shortening of the supply chain; 6. More efficient channels of product distribution and forecasting;</td>
<td>1. Building and developing an appropriate digital infrastructure for communications and connectivity; 2. Investments for modernization and technologies for precision agriculture; 3. Development of digital networks and use of software applications in activity management and decision-making; 4. Training and consulting to develop digital skills and qualifications; 5. Research and innovation, partnership for exchange and transfer of innovations, development of infrastructure for</td>
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</table>
6. Attracting high-tech talent to agriculture; 8. Reduction of fraud; 10. Improving the working conditions of farmers.

7. Effective control over the quality of production; 9. Diversification of production and minor costs; 6. Development of digitalization of public administration and administrative services in the "Agriculture" sector;

8. Effective control over the introduction of new crops. 7. Use of "Blockchain" technology in the "Agriculture" sector; 8. Smart Villages (Smart villages);

Source: author’s summary

In the Concept for the development of artificial intelligence in Bulgaria until 2030, agriculture is defined as a consumer sector of AI. The strategy is expected to play an important role in the implementation of the development policies set out in "Bulgaria 2030" and, more specifically, sustainable agriculture.

In accordance with the objectives of the EU policy for the development of rural areas, the Program for the Development of Rural Areas for the period 2014-2020 is the main strategic document for the implementation of the Second Pillar of the CAP in Bulgaria in the period 2014-2020. Currently, a working group has been created and work is underway to adopt a Strategic Plan for the CAP in the period 2023-2030.

The following strategic documents also relate to innovations in the agricultural sector - National strategy for the development of scientific research in the Republic of Bulgaria 2017-2030 in the part "Better science for a better Bulgaria" and National Science and Research Fund as a secondary authority to the Ministry of Education and Science, is the main tool for funding of scientific research on a competitive basis in the country. It is written in the strategy that the Agricultural Academy (AA), some of the institutes of the Bulgaria Academy of Science (BAS) and Higher Education (HE) develop the various agrarian sciences, as a large part of these scientific fields correspond to the priority areas of ISIS.

For the implementation of the strategic documents in the field of research and innovation activity, the main sources of funding are laid down in the National Plan for Recovery and Sustainability, the national budget through the National Innovation Fund (Ministry of Economy), National Science and Research Fund, Ministry of Agriculture (CAP 2023-2027) and others.

RESEARCH AND INNOVATION POTENTIAL OF THE AGRICULTURAL SECTOR (RESULTS)

Bulgaria has a long history in the development of innovations in agriculture, both from the universities and from various scientific units and other institutions. The concept of the innovation system in the agricultural sector makes it possible to cover all participants in the processes of creation, transfer, dissemination and application of new knowledge and technologies both in the field of agriculture and in all related spheres, the
existing and potential interactions between them, the impacts of side of European and national politics, the influence of factors such as funding and quality of human resources. In this way it is achieved:

- Emphasis on factors promoting innovation activity originating outside the system, which can find a new application or stimulate the effective use of other internal factors;
- The generation of a critical mass is encouraged in terms of used resources and exchange of ideas at the expense of the isolated performance of individual functions in service of the innovation process;
- Innovations dictated by novelties in science and technological development, and to those originating from changes in the market and the behaviour of end users;
- Interaction within the sector on the individual units of the technological chain on the basis of coordination of activities, generation of knowledge, multiplication of results stands out;
- An opportunity to build the innovation capacity of the individual participants in the system and of the system as a whole through systematic and coordinated efforts dictated by the opportunities of the research units, the educational system and the business;
- Development of an innovation culture and an environment supporting innovation through approaches and measures that are adapted to the needs of the system and the goals for its development.

Ecosystem participants are many and varied in their structure, funding and capacity. It is important to point out that the ecosystem is dynamic and includes both already built and newly built research and innovation infrastructures, which requires additional monitoring. The different participants in the Agricultural Knowledge and Innovation System (AKIS) contribute differently to management and financing, for the initiation, creation, distribution and the implementation of knowledge and innovation in the industry.

In addition to the diverse types of farmers and farms, this complex system includes scientific institutes, universities and schools, agricultural advisory services, private consultants, specialized consulting, training and innovation companies, professional organizations of agricultural producers, non-governmental organizations, suppliers of technology, chemicals and innovation, food chains, processors and exporters of agricultural products, government agencies, local authorities, non-governmental organizations and interest groups, media of various kinds, international organizations, private individuals, etc. (Agricultural Academy, Institute for agrarian economy, 2020).

In the agricultural sector, R&D is mainly carried out by the state sector - scientific institutes and experimental stations of the Agricultural Academy, the Centre for Plant and System Biology and Biotechnology, part of the institutes of the BAS and HEIs. All accredited universities are state-owned, accredited as follows:

<p>| Table 4. Accredited universities in the field of higher education: 6. Agricultural sciences and veterinary medicine. |</p>
<table>
<thead>
<tr>
<th>HEIs</th>
<th>6.1 Plant breeding</th>
<th>6.2 Plant protection</th>
<th>6.3 Livestock breeding</th>
<th>6.4 Veterinary medicine</th>
<th>6.5 Forestry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural University - Plovdiv</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Trakia University - Stara Zagora</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>University of Forestry</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
In addition to the above-mentioned HEIs, which are state-owned, other HEIs accredited in other professional areas (mainly in professional fields 3.8 Economics and 3.7 Administration and Management) should be considered as working at the sectoral level in the agricultural sector. Such HEIs are Higher School of Agribusiness and Development the regions - Plovdiv or all others with structural units or specialties - such as University of World and National Economy, "D. Tsenov" Svistov Academy, Sofia university “St. Kliment Ohridski” and others.

The digital innovation hub (AgroHub) and the European digital innovation hub (AgroDigiRise) are important stakeholders in AKIS. Among the more significant scientific research complexes and centers with a contribution to the economic growth of Bulgaria included in the National Roadmap for Scientific Infrastructure, developed by the Ministry of Education, three centers included in the pan-European infrastructures in the field of biomedicine, health and food; eleven centers, part of the national R&I complexes in the field of "Healthy Life Industry and Biotechnologies", directly and/or indirectly related to the agricultural sector.

From projects, part of the national science and innovation complexes of key importance for the development of the competitiveness of the Bulgarian economy and technological base, from the thematic area "Industry for a healthy life and biotechnologies", the following were financed:

- Center for Plant System Biology and Biotechnology;
- National Infrastructure for Research and Innovation in Agriculture and Food (RINA);
- Research infrastructure in the field of food, nutrition and health, tied to Bulgaria's participation in pan-European infrastructure;
- Competence center "Sustainable utilization of bio-resources and waste from medicinal and aromatic plants for innovative bioactive products" coordinated by the Institute of Organic Chemistry with the Center for Phytochemistry at the BAS, in partnership with the Agrobio-Institute at the Agricultural Academy and other organizations and a budget of 23.8 million BGN
- Plant Health Diagnostics and Technologies Center (PLANTHELT), a consortium between the Forestry Institute at BAS, Agricultural University - Plovdiv and Trakia University - Stara Zagora.

The territorial coverage, the scientific infrastructure in the field of agro-bio science is throughout the country (via institutes of the Agricultural Academy). In the Southwestern region and mainly in the capital of Bulgaria, there are 8 scientific institutes, one university and Sofia Tech Park. Three institutes and three universities are located in Plovdiv - South Central region. There are 3 institutes and one university in the Southeast region. There are 2 institutes in the North-East region. In the North Central region we have 4 institutes, the exception is the North Western region, where there is no scientific infrastructure.
The main centers for making managerial decisions within the sectoral innovation ecosystem of agribusiness in Bulgaria are distributed between those responsible for policies in the field of scientific research and innovation, scientific organizations and HEIs creating new knowledge and technological solutions, organizations and structures for the dissemination of knowledge and information, as well as organizations applying new technologies.

The national research and innovation policy is implemented by the Ministry of Education, the Ministry of Innovation and Growth and the expected new Law for the Promotion of Scientific Research and Innovation. In the agrarian sector, the leading place is occupied by the Ministry of Agriculture and Food (new CAP 2023-2027) together with the National Plant Protection Service and the Agricultural Academy, as well as the Ministry of Economy (National Plan for Recovery and Sustainability, National Innovation Fund), Ministry of Education (National Scientific Research Fund) and others.

The creation of new knowledge and technological solutions is mainly carried out by scientific organizations and universities. The inherited fragmentation between institutions and units engaged in fundamental and applied research and training is in the process of transformation in the direction of reconciliation, sharing, multiplication of functions and activities in order to reflect the multidisciplinary nature of innovation processes, the need to search for complex solutions, shortening time and optimizing efforts in the process of creating and applying new technologies.

The data from the register of scientific activity in the Republic of Bulgaria, maintained by the Ministry of Education and Science through the National Center for Information and Documentation in professional field 6. Agricultural Sciences and Veterinary Medicine, a total of 36 organizations are registered. Of these, 23 are part of the Agricultural Academy (with experimental stations), BAS with 2 institutes (Institute of Reproductive Biology and Immunology "Acad. Kiril Bratanov", Institute of Organic Chemistry with a Phytochemistry Center), accredited universities with their affiliates/units: Agricultural university - Plovdiv, Trakia University - Stara Zagora (with 3 registered organizations), Konstantin Preslavski" University of Shumen, Higher School of Agribusiness and Regional Development - Plovdiv, Technical University - Varna, Forestry University. NGOs are included with two organizations Bulgaria association for biological plant protection, National Biomass Association, and from the business organizations only M-AGRO EOOD.

An important prerequisite for increasing the innovative activity of the sector is the new knowledge created by the scientific organizations and scientists included in it. The analysis of the dynamics and structure of this process reveals the potential of the units of the innovation system to successfully fit into global scientific networks, the country's comparative advantages in this area of knowledge and the ability to successfully compete on the market of intellectual products. Proof of this is the data on scientific publications in the field of the agricultural sector, indexed and referenced in the world databases compared to other Eastern European countries.
Table 5. Publications in Agriculture and Biological Sciences, Region Eastern European (April 2022)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Documents</th>
<th>Citable documents</th>
<th>Citations</th>
<th>Self-citations</th>
<th>Citations per document</th>
<th>H index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Russian Federation</td>
<td>75776</td>
<td>74785</td>
<td>692949</td>
<td>206201</td>
<td>9,14</td>
<td>214</td>
</tr>
<tr>
<td>2</td>
<td>Poland</td>
<td>68756</td>
<td>67922</td>
<td>915842</td>
<td>258252</td>
<td>13,32</td>
<td>208</td>
</tr>
<tr>
<td>3</td>
<td>Czech Republic</td>
<td>44677</td>
<td>43838</td>
<td>704294</td>
<td>166608</td>
<td>15,76</td>
<td>210</td>
</tr>
<tr>
<td>4</td>
<td>Hungary</td>
<td>22520</td>
<td>22009</td>
<td>381293</td>
<td>62058</td>
<td>16,93</td>
<td>191</td>
</tr>
<tr>
<td>5</td>
<td>Slovakia</td>
<td>14603</td>
<td>14433</td>
<td>169679</td>
<td>33615</td>
<td>11,62</td>
<td>129</td>
</tr>
<tr>
<td>6</td>
<td>Croatia</td>
<td>13198</td>
<td>13010</td>
<td>160781</td>
<td>32359</td>
<td>12,18</td>
<td>126</td>
</tr>
<tr>
<td>7</td>
<td>Serbia</td>
<td>12147</td>
<td>11929</td>
<td>131155</td>
<td>28508</td>
<td>10,8</td>
<td>108</td>
</tr>
<tr>
<td>8</td>
<td>Ukraine</td>
<td>10649</td>
<td>10542</td>
<td>82491</td>
<td>16073</td>
<td>7,75</td>
<td>99</td>
</tr>
<tr>
<td>9</td>
<td>Romania</td>
<td>10566</td>
<td>10433</td>
<td>113223</td>
<td>19706</td>
<td>10,72</td>
<td>110</td>
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<tr>
<td>10</td>
<td>Bulgaria</td>
<td>9305</td>
<td>9141</td>
<td>114082</td>
<td>14262</td>
<td>12,26</td>
<td>117</td>
</tr>
<tr>
<td>11</td>
<td>Slovenia</td>
<td>8856</td>
<td>8711</td>
<td>175398</td>
<td>23761</td>
<td>19,81</td>
<td>138</td>
</tr>
<tr>
<td>12</td>
<td>Estonia</td>
<td>7112</td>
<td>6940</td>
<td>194252</td>
<td>29751</td>
<td>27,31</td>
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<tr>
<td>13</td>
<td>Lithuania</td>
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<td>5680</td>
<td>70647</td>
<td>12459</td>
<td>12,24</td>
<td>97</td>
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<tr>
<td>14</td>
<td>Latvia</td>
<td>4760</td>
<td>4728</td>
<td>36463</td>
<td>6890</td>
<td>7,66</td>
<td>72</td>
</tr>
<tr>
<td>15</td>
<td>Belarus</td>
<td>1663</td>
<td>1653</td>
<td>17229</td>
<td>1425</td>
<td>10,36</td>
<td>57</td>
</tr>
</tbody>
</table>

Source: Scimago Journal and Country rank

The data for Bulgaria indicates a significant lag compared to the publications from the leaders Russia, Poland and the Czech Republic, with a relatively low degree of self-citation, but with a high number of citations per document and h-index levels.

![Figure 5. Ratio of H-index to average number of citations per publication in Agricultural and Biological Sciences](https://www.scimagojr.com/)

The detailed analysis of the publication activity in Bulgaria indicates that with the highest degree of citation and h-index levels are publications in the field of plant breeding, ecology, food industry, and the authors are mainly from a limited number of state HEIs such as Medical University, University of Food Technologies – Plovdiv, Trakia University, Sofia university and the institutes from Bulgarian Academy of Science (BAS), where the Institute of Biodiversity and Ecosystem Studies - Sofia stands out. The publication activity is not
balanced among the accredited universities in the field of agricultural sciences, as there are also a large number of interdisciplinary scientific researches and publications.

The publications in SCOPUS of the Agricultural Academy with all its structural units in the period 2000-2022 are a total of 1464, distributed by year as follows:

Figure 6. Scopus indexed publications of Agricultural Academy

Source: Scopus

By editions, the most publications are in the Bulgarian Journal of Agricultural Science (403), which is a edited by Agricultural Academy(AA), followed by those in Biotechnology and Biotechnological Equipment (191) of Tylor & Francis, Acta Horticulturae (38). The publications in the field of agricultural sciences - by affiliation stand out AA (991), Agrobioinstitute - Sofia (552), BAS (253), Institute of Animal Breeding Sciences - Kostinbrod (170), Sofia University (115), Institute "N. Pushkarov" (102), Institute of Biodiversity and Ecosystem Research (73), Institute of Agrarian Economics (67), Trakia University (63), Unoversity of Food Technology – Plovdiv (57), Agricultural University - Plovdiv (55), Institute of Plant Physiology and Genetics (53), Plovdiv University (49), Forestry University (33) and others.

Figure 7. Scopus indexed publications by affiliation

Source: Scopus
In terms of funding sources, the majority is state-funded through the National Science Research Fund (125 publications), the Ministry of Education and Culture (158), followed by publications funded by the EU (40), supplemented by those under the Seventh Framework Program (26).

Figure 8. Number of publications by funding source.
Source: Scopus

In terms of thematic content, the publications are mainly in three sub-fields: agricultural and biological sciences (37.4%), biochemistry, genetics and molecular biology (17.7%) and veterinary medicine (16.9%).

Figure 9. Distribution of issued patents in Bulgaria by sections and technological areas up to class level of IPC, 2001-2022, number
Source: Bulletins of the Bulgarian Patent Office; own calculations
Protected new technological knowledge is the result of the creative activity of various participants in the innovation process, has unique characteristics and economic significance that make it attractive as an object of transfer. The analysis of the applicant and patent activity, as well as the attitudes of Bulgarian and foreign persons in this field, allow to evaluate an essential aspect of the functioning of the innovation system and to look for ways to improve it.

Figure 10. The distribution of patents issued in Bulgaria to Bulgarian patent holders by sectors and sections of the Classification of Economic Activities, 2001-2021 (number)

Source: Bulletins of the Bulgarian Patent Office

The distribution of the issued patents of Bulgarian patent holders in Bulgaria, by sections and technological directions up to class level of the International Patent Classification (IPC) is shown in Figure 10, and the distribution of patents issued in Bulgaria to Bulgarian patent holders by sectors and sections of the Classification of Economic Activities in Figure 11. Most of the patents are A01- AGRICULTURE; FORESTRY; ANIMAL HUSBANDRY; HUNTING; TRAPPING; FISHING and in A23- FOODS OR FOODSTUFFS; TREATMENT THEREOF, NOT COVERED BY OTHER CLASSES. Together, A01 and A23 represent 94% of all issued patents in the period 2001-2021. The dynamics during the research period outlines high levels during 2002-2011, followed by a period of almost zero activity (2011-2017) and gradually activation in the number of issued patents.

The trend of extremely low patent activity in the Higher Education sector in the period 2011-2022 is interesting, as from the accredited universities in professional field 6. Agricultural Sciences and Veterinary Medicine, only 1 patent was registered (2021) from the Agricultural University - Plovdiv, while in the period 1994-2001, nearly 10% of the total number of patents in the sector were owned by the Agricultural University, Plovdiv (17 out of a total of 136 patents). In the private sector, only 49 of the patents with possible application in the agri-food sector are owned by businesses.
A significant contribution to the innovation ecosystem is expected to be generated by a number of national scientific programs funded by the Ministry of Education, which are in the process of implementation, directly aimed at the agricultural sector:

![Figure 11. Patent activity of structures and units at the Agricultural Academy, 2001-2021.](image)

*Source: Bulletins of the Bulgarian Patent Office*

National scientific program "Healthy foods for a strong bioeconomy and quality of life", a consortium with leading partner Agricultural University - Plovdiv, together with the Agricultural Academy; Bulgarian Academy of Sciences; University of Food Technologies - Plovdiv; Sofia University "St. Kliment Ohridski"; Trakia University - Staro Zagora. The program addresses societal challenges for a more innovative, resource-efficient and competitive society. Indicative budget BGN 6.0 million.

National scientific program "Intelligent plant breeding" is implemented by a consortium with a leading partner Agricultural University - Plovdiv, together with the Agricultural Academy; Bulgarian Academy of Sciences; Trakia University - Staro Zagora, Ruse University "A. Kanchev", National Institute of Meteorology and Hydrology, Higher Naval School "N. Y. Vaptsarov" - Varna. The program aims to conduct fundamental and applied scientific research to create models for robotic technologies, digital methods for diagnosis and forecasting, as well as for digital management of agricultural holdings with a crop production direction to ensure a sustainable and efficient food system. Implementation period 2021-2024 and budget BGN 4.5 million.

National scientific program "Intelligent animal husbandry" is implemented by Trakia University - Staro Zagora, Agricultural University - Plovdiv, Sofia University "St. Kliment Ohridski", Technical University - Sofia, BAS (Institute of Information and Communication Technologies, Institute of Mechanics, Institute of Reproductive Biology and Immunology), AA and a number of associated partners. Implementation period 2021-2024 and budget BGN 4.5 million.

National scientific program "Reproductive biotechnology in animal husbandry in Bulgaria" (REPROBIOTECH) aims to optimize the reproductive process in animal husbandry through the implementation of innovative biotechnology and knowledge transfer. The specific objectives of the program are related to reproductive biotechnology in animal husbandry - use of fresh and cryopreserved genetic material; improving the reproductive potential by using non-hormonal bioactive supplements during periods important for reproduction; knowledge transfer and reproductive biotechnologies.
The National Infrastructure for Research and Innovation in Agriculture and Food - (RINA, Research, Innovation, Agriculture) is a consortium of scientific institutes that will upgrade existing scientific and service units and unite them in 5 research complexes in the main thematic directions of the agrarian science - sustainable management of soil resources, efficient use of water and definition of environmental risks and threats; genetic research and plant selection; food and beverage research; livestock, fisheries and aquaculture research; agro-information, agro-management and rural development. The goal is to create a modern national research infrastructure for achieving significant scientific and applied results, transfer of knowledge and technology in the field of agriculture, food and natural resource protection and an active partner in the creation of clusters between science, agrarian and processing business.

The national infrastructure also includes the Center for Plant System Biology and Biotechnology including 10 research departments in the field of plant system biology and biotechnology, plant breeding, genomics, molecular biology, metabolomics, bioinformatics.

Bulgaria is participated in European infrastructure under the project "STRENGTHEN RESEARCH AND INNOVATION CAPACITY FOR GRAZING LIVESTOCK MEAT PRODUCTION IN BULGARIA THROUGH ADVANCED KNOWLEDGE TRANSFER" - "GREENANIMO", financed by the National Program "European Scientific Networks" with participation of the Faculty of Agriculture and Veterinary Medicine of Trakia University, the French National Institute of Agrarian Sciences and Ecology (INRAE) and the Scottish Agricultural College (SRUC).

Dissemination of information and knowledge and provision of consulting services are carried out primarily by the units of the Ministry of Agriculture and Food. Within the education system, there are specialized units for knowledge transfer, but the services provided are not of a systematic nature. Greater independence in the performance of these functions was achieved through the launch of the LEADER-initiative, although in this case the funding was public. Among the main reasons for this are a) the large number of small farms with severely limited financial resources, resp. opportunities to use similar services on a market basis; and b) the government's desire to maintain its influence on the development of the sector by implementing specific policy measures. The representatives of the private sector with relevant functions are depleted with rather sporadic appearances of large companies that provide services in addition to new and improved products; small independent consulting firms and consultants oriented towards the provision of specialized assistance; non-governmental organizations whose portfolio depends on donor organizations at a certain point and in this sense cannot claim sustainability.

European Digital Innovation Hubs (EDIH) and Digital Innovation Hubs (DIH) are expected to make a significant contribution to the dissemination of information and knowledge. At the national level, out of a total of 17 ECIH applicants, only one is targeted in the agricultural sector - AgroHub. BG "Developing the innovative potential of the agricultural sector in the perspective of "precision agriculture" and supporting the overall digital transformation and development of the South Central Region". Of the remaining Bulgarian candidates for EDIH, although they are directed to other thematic areas than ISIS, they have indicated that they are related to the agricultural sector, a total of 4 hubs of which 2 have been approved, 2 are in the process of approval. These are European Digital Innovation Hub Zagore (candidate), Next-Gen-BioTech Digital Innovation, RIC Digital Future, Trakia Digital Innovation Hub (candidate).

At the European level, following the Strategy for the digitalization of the European economy within the Horizon 2020 program, the SmartAgriHubs project has been selected in agriculture, in which the Bulgarian AgroHub.BG also participates.

In 2022, AgroDigiRise was created, which builds on the existing AgroHub.BG and was approved for the EDIH of the South Central Region of Bulgaria. Its main objective is to support the region - SMEs and in particular the food industry
sector - in its digital and green transformation by providing an integrated portfolio of services targeting the identified needs; connecting fragmented ecosystems of various digital solution providers and end-users with academia and the public sector with increasing competitiveness and the green transition. To better support the ecosystem, AgroDigiRise aims to expand its services and capacity by building a National Demonstration Center (NDC) and a network of Demo Points (DP) in other agriculturally relevant regions across the country as the needs are similar. This, combined with the laboratories and technology provided by partners, will provide the necessary infrastructure to support precision agriculture. The ultimate goal is to create a network of an active and complex ecosystem of stakeholders interacting with each other to achieve common goals.

EIT Food is the leading European food innovation initiative working for a more sustainable, healthy and reliable food system. EIT Food is a pan-European consortium focusing on entrepreneurship and innovation in the food sector. The members of the EIT Food community are leading organizations in the international food field: more than 50 partners from companies, research centers and universities in 13 countries. This is the largest public-private innovation partnership focused on the agricultural and food sector, to create an EIT Food Hub in Bulgaria, through participation in the EIT Regional Innovation Scheme (EIT RIS). The EIT RIS is a structured scheme to support the integration of the knowledge triangle (education, research, business) and increase innovation capacity in regions in Europe that do not yet directly benefit from the EIT and its programmes.

At the beginning of 2021, with the aim of supporting business creation activities and the start-up ecosystem in the agri-food sector, a consortium was created between the Agricultural University-Plovdiv and Cleantech Bulgaria OOD with the support of the Sofia University "St. Kliment Ohridski". The consortium was established within the framework of an international project of the European Institute for Innovation and Technology in Food (EIT Food) to act as the EIT Food Hub for Bulgaria in the period 2021-2023. The consortium will act as an innovation network supporting activities to create business and the start-up ecosystem in the agri-food sector, representing different actors in the knowledge triangle (education, research, business). The hub is envisioned to act as a catalyst for partnerships to increase uptake of knowledge and skills by players and stakeholders in the food industry sector, facilitate the participation of students, researchers, entrepreneurs, start-ups, industry representatives and experts in the programmes of EIT Food and initiatives at the European level, creating conditions to support the development of start-up companies in the food industry, transfer of scientific knowledge and innovative technologies and joint participation in national and international programs and projects.

The application of new technologies is determined by the end-users of innovative technologies in agriculture, family farms that produce products primarily to satisfy their own needs, making up about 80-90% of all structures in the sector; family farms, whose production is mainly market-oriented while also satisfying their own needs, about 15-20%; large farms (no more than 3-5%) with significant resources (cultivable area, machinery, finance, technology), specialized in the production of certain final products and fully integrated with national/international markets. Within Horizon Europe, according to the priority "Food, bioeconomy, natural resources, agriculture and environment", only 5 Bulgarian MPS participate - Pensoft Publishers (3), Denkstatt Bulgaria OOD, Okis OOD, Association of local initiative groups Troyan, Apriltsi, Ugarchin, Tech Tour Global, but this activity is extremely low for the sector as a whole.

Although the food industry sector is a major economic force, many farmers face difficulties in starting modernization due to insufficient information about digital technologies and their possibilities, lack of digital skills and knowledge necessary for the implementation process, difficult access to technological expertise and investments (Agricultural Academy, Institute for agrarian economy, 2020) to contribute to the preparation of the CAP Strategic Plan 2021-2027).
This leads to low investment activity, followed by difficult penetration of modernization and weak implementation of modern technologies and innovations.

As a result of the slow and difficult modernization in the sector, problems related to inefficient production efficiency and the quality of human potential are clearly emerging. This reduces the competitiveness of farmers and limits their opportunities for sustainable business development, which has a serious impact on the entire agri-food chain and the local economy. However, the need for digitization in the country - and in particular in the agricultural sector - is recognized and benefits are seen in increasing the efficiency of processes and services, reducing costs, better planning and management, increasing productivity, collecting and analysing data. But there is still a lack of a unified state policy for modernization, as well as overall support in this process.

The unmodernised agricultural sector also has a negative impact on nature and the environment, in particular in terms of resource wastage (water due to an unmodernised irrigation system), excessive use of fertilizers, groundwater pollution with nitrates, and high average nitrogen rate per unit area (Popov A., Stoilov I., Vodenska M. and team, 2020).

CONCLUSION

A comprehensive assessment of the innovation ecosystem at the national and regional level in the agricultural sector has not been done due to a lack of sufficient official information and statistical data on its state and development, as well as due to the difficult to measure relationships between the participants, which are dynamic and the system itself open.

The analysis of the state, the potential for development and the intra-systemic interaction between the units of the sectoral innovation ecosystem of the agricultural sector contrasts the following potential opportunities and challenges.

In the agricultural sector, there is a large fragmentation of cultivated land. The country is dominated by small producers (Mishev P., Atanasov A. et al., 2009), a large number of small fragmented farms without sufficient capacity, are characterized by low-skilled personnel, low innovation culture, lack of interaction. Uneven development of agricultural sub-sectors, leading to deterioration of production results, weak interaction between sub-sectors and inefficient use of land and other resources.

In terms of the level of interaction, including: institutional (AA is a secondary allocator of budget credits within the Ministry of Agriculture and Food); functionally (AA offers training for PhD students, training and consulting services in relation to business; universities carry out fundamental research) there is a formal basis of interaction, which, however, does not lead to acceleration and facilitation of the process of implementation of new technological solutions along the chain of production of final products agribusiness products. The connections between universities and scientific institutes, scientific institutes – National Agricultural Advisory Service (NAAS), NAAS and agricultural producers and NGOs, private companies and consultants have been assessed as highly effective. The connections between individual universities, universities - agricultural producers, private companies and consulates are low efficiency; scientific institutes with agricultural producers, private companies and consultants; NAAS with private companies and consultants; of the
associations of producers between them and with private companies and consulates as well as between the agricultural producers themselves.

A high degree of geographical decentralization of research and university units located in the areas of application of the relevant knowledge/services. The decentralization of the research activity of the AA in 25 regional units allows scientific coverage of the territory of the entire country.

Practical-applied oriented research activity, both within the framework of AA and HEIs research projects and service activities bring the results of scientific activity as close as possible to the problems of agricultural holdings, solved on their basis. However, the implementers are the least ready in terms of financial capabilities, scale and competences to implement the results of scientific developments.

Effective mechanisms for the rapid application of scientific achievements in practice - highly productive varieties and new breeds of animals, complex technologies for soil treatment and production of agricultural products - have not been created. Medium and small farms are not informed about the possibilities for joint activity with the institutes of the AA. Low levels of engagement/cooperation/interaction between farmers and public intermediary structures, largely due to lack of vision and strategy in service delivery; lack of resources (financial and administrative capacity); a standard approach to the provision of services, inconsistent with the specific needs of the persons/farms to which they are directed. A large number of industry associations. Absent or weakly developed cluster structure.

Lack of strategic vision, understanding of the importance and ineffective use of intellectual property. Lack of up-to-date, detailed and systematized information. Data on registered patents, on the one hand, show relatively high activity among AA and BAS, limited by HEIs and highly selective by the private sector.

Limited investment in new technology, innovation and research. Scarcity and low quality of raw materials. Lack of cost-effective technologies and equipment. A study from 2019 dedicated to the effectiveness and development factors of the system for sharing knowledge, innovation and digitalization in agriculture (AKIS) (Bashev H., Mihailova M., 2019) confirms empirically, identified the main features of the Bulgarian innovation ecosystem in the agricultural sector. Low level of public costs and investments for digitization in the agrarian sphere, for agrarian research and for the implementation of agrarian innovations and for agrarian advice and training. Scientific institutes and universities stand out as the most active and significant for the development of new products, methods, technologies, varieties and information. Agricultural advisory services lead for consultation and advice, while digital services stand out for universities, media and the internet.

The private companies and organizations, producers' organizations and NGOs are defined as having the highest financial security. The assessment of financial security mainly of scientific institutes and stations and to a lesser extent of universities is unsatisfactory. There is a high potential for agrarian research and consultation in the main participants in the AKIS - especially in the universities and scientific institutes.

There is an imbalance and a different degree of efficiency regarding the degree of use of advice and implementation of innovations in the sector. The biggest innovators are legal entities of various types, followed
by commercial companies. There is also a large imbalance in terms of the size of farms and holdings, as innovative, applying new technologies and digital solutions, precision agriculture and automation mainly large farms and farms. Among the factors for improving the spread of knowledge, innovation and digitalization, consumer demand, product prices, competition and subsidies for new investments, as well as the activity of the National Agricultural Advisory Service (NAAS) stand out.

Need for direct interaction between farmers and hands-on observation of good practices/results and profitability to foster motivation and willingness to expand and transfer knowledge into practice. Studies show that most farmers self-identify as innovative, but practice shows other results. This includes the stimulation of an integrated approach - face-to-face contacts on the farm and digital solutions, with web-based information exchange. The participation and commitment of agricultural producers is also a prerequisite for faster dissemination of information. Joining or creating an online knowledge network will help farmers quickly connect with a wide range of partners.

The development of the agricultural sector and the food industry and the creation of their basis of national competitive advantages depends on the innovation activity of the units of the sectoral innovation system. Innovation is the most important factor in increasing productivity and overcoming the sources of social inequality. The development of innovation potential should be based on the implementation of policies/addressing of measures that are relevant to the potential of the units of the innovation ecosystem and the priorities for their development; the orientation of innovation processes to the needs of practice and the possibilities of application, at the same time under conditions of high return and conversely positive impact on the innovation ecosystem as a whole; the creation of intermediate units to act as a natural bridge between the participants in the innovation process, to orientate/translate the newly created knowledge into the language of those who will apply it.


All authors have read and agreed to the published version of the manuscript.


Institutional Review Board Statement: not applicable

Informed Consent Statement: Informed consent was obtained from all the participants involved in the study.
Data Availability Statement: The data presented in this study are available on request from the corresponding author.

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Conflict of interests
The authors declare no conflict of interest.

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THE PURPOSE OF THE NATION

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Speech

August 22, 2022
09.30 – 12.30 PLENNARY SESSION AND ROUND TABLE
Taras Shevchenko National University of Kyiv
Educational and Scientific Institute of Public Administration and Civil Service

THE INDEPENDENCE OF UKRAINE: MODERN DOCTRINE AND PRACTICE OF PUBLIC ADMINISTRATION

Director of the Educational and Scientific Institute of Public Administration and Civil Service of Taras Shevchenko National University of Kyiv, Ms. Larysa Komakha has the honor to invite Professor, Doctor of Philosophy Jan-Urban Sandal to join the International Round Table and to address its participants with a welcome speech

Dear
Volodymyr Bugrov, Rector of Taras Shevchenko National University of Kyiv, Candidate of Philosophy, Professor, recipient of award for excellence in education of Ukraine, Honored Worker of Education of Ukraine, Larysa Komakha, Director of the Educational and Scientific Institute of Public Administration and Civil Service of Taras Shevchenko National University of Kyiv, Doctor of Philosophy, Professor,
Members of the main table,
Distinguished Guests,
Ladies and Gentlemen,

August 24 is the date to celebrate Ukraine's independence. We gather today as scientists, representatives of state authorities and local self-government bodies, representatives of international organizations, as well as doctoral students, postgraduates and students of higher education and other interested persons and institutions, to discuss, at the international round table the achievements and prospects of independent Ukraine, to find ways to overcome modern challenges for the state. Ukraine has successfully accomplished achievements in recent decades and is now seeking prospects and vision for its future development. International independent science is a thorough and proven method in all spectrums of innovative-based democratic development, as its duty is the scientific truth.

Therefore, invest your trust in international independent science and build the future, not on modern or false ideologies, which change directions with the blowing winds, but build Ukraine's independence on the wisdom of eternal values that come not from any kings or generosity of states, but from the laws of nature.

A nation with a purpose will stand. A nation without a purpose cannot stand, and will consequently fall. This is not a self-fulfilling prophecy. This is the reality. Do not look to the north or south, do not look to the east or west. Look at yourself. You have everything you need. A standing nation is a nation with deep and long-lasting roots. A standing nation is governed based on the will of the people. A standing nation provides a good life for all. A standing nation is a good home for all its citizens, young and old, male and female, poor and rich, healthy and sick, strong and weak, stranger and friend. A civilized nation is founded by civilized men, and it strengthens and contributes to further development of civilization. The civilized man does not accept inequality, discrimination, privileges, corruption, threats, violence, oppression, slavery, but guides the nation as his own family with respect for the inviolability of life that all men are created equal and are perfectly suited to face every challenge in life in search of happiness.

I welcome you all with the paramount and eternal words joy, peace and liberty.

Rector, Director, Members of the main table, Distinguished Guests, Ladies and Gentlemen:

Thank you very much for the attention.

Prof. h. c. multi Doctor h. c. multi. Fil. Dr. Jan-Urban SANDAL

Executive Director and Owner of Fil. Dr. Jan-U. Sandal Institute

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e) References.

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