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Abstract

In order to make positive socio-economic transformations, the concept of the sustainable development was proposed and it can be implemented through the innovation. And startups are among the modern innovation drivers. So, the aim of the research was to identify the key startup success factors and to develop an instrument for startup success evaluation in order to minimize the loss of time and resources and partly overcome the high uncertainty rates, specific to the startup industry, using multidisciplinary approach and, in turn, contribute to the sustainable development implementation. It was found that there are three main constituents which influence the startup success – an external environment, startup activity and an internal startup environment. The determined success factors were analyzed according to the groups which correspond to these constituents. The mathematical model in the form of the Bayesian network for evaluation and prediction of the startup success was developed. It was found that the modeled startup success probability is most likely to be of a low or an average level. The conditional probabilities distribution for the startup success was also analyzed. The developed model can be used for the startups success levels determination in a particular country, specific market, etc.

Keywords: startup success, Bayesian network, sustainable development, startup marketing strategy, socio-economic transformations

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El Desarrollo Exitoso de Startups como un Trend Global de Transformaciones Socio-economicas Innovativas

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Resumen

Para lograr transformaciones socioeconómicas positivas, se propuso el concepto de desarrollo sostenible y se puede implementar a través de la innovación. Y las startups se encuentran entre los impulsores de la innovación moderna. Por lo tanto, el objetivo de la investigación fue identificar los factores clave de éxito de startups y desarrollar un instrumento para la evaluación del éxito de startups con el fin de minimizar la pérdida de tiempo y recursos y superar en parte las altas tasas de incertidumbre específicas de la industria de startups, partiendo de un enfoque multidisciplinar y, a su vez, contribuir a la implementación del desarrollo sostenible. Se descubrió que hay tres componentes principales que influyen en el éxito de los startups: el entorno externo, la actividad de startups y el entorno interno de startups. Los factores de éxito determinados se analizaron de acuerdo con los grupos que corresponden a estos constituyentes. Se desarrolló el modelo matemático en forma de red Bayesiana para la evaluación y predicción del éxito de la startup. Se encontró que la probabilidad de éxito de la startup modelada es más probable que sea de un nivel bajo o promedio. La distribución de probabilidades condicionales para el éxito de la puesta en marcha también se analizó. El modelo desarrollado se puede usar para la determinación de los niveles de éxito de las startups en un país en particular, un mercado específico, etc.

Palabras clave: éxito de startups, redes Bayesianas, desarrollo sostenible, estrategias de marketing de startups, transformaciones socioeconómicas

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Changes in the contemporary world often lead to the unforeseen consequences, growing uncertainty and problems that constantly arise all over the world. And today the emergence of such problems is even more dangerous than ever because of the globalization and interdependence between economies and societies. In particular, Young et al. (2006) state that globalization is the key feature of the socio-ecological systems and thus, it influence their vulnerability, resilience and adaptability. At the same time, Sapir (2006) states that globalization cause changes which not only bring new opportunities, but also create threats. The existence of the globalization influence on economy and business was also proved in many papers. For example, Vinig and Kluijver (2007) have found that in countries with a low GDP the negative impact of globalization on the entrepreneurship can be observed. Furthermore, today crises in one sphere lead to the worsening of the situation in others. For example, degradation of the environment and depletion of natural resources, as well as water, soil and air pollution cause hazardous social issues due to the lack of food and clean water, diseases amplification, etc.

In order to prevent global crises, make positive social transformations and impact on the environment, the concept of the sustainable development of society and biosphere was proposed. In general, this concept is aimed at balancing of social, ecological and economic development, but, according to Hopwood, Mellor, and O'Brien (2005), scientists use it with different meanings – for example, it can be considered as an endeavor for combination of the concerns about environmental issues with socio-economic ones. The positive impact of the sustainable development implementation was proved by multidisciplinary scientific investigations. For example, Dean and McMullen (2007) determined that sustainable entrepreneurship can help to solve the environmental degradation problems in the socio-economic systems. In turn, Broman and Robèrt (2017) studied the peculiarities of the framework for the strategic sustainable development and effects of its implementation. Clark et al. (2016), Hall, Daneke, and Lenox (2010), as well as Kolk and van Tulder (2010) also made contributions to the cultivation of sustainability concept in terms of the social and economic development.

The conducted investigation has shown that sustainable development can be implemented through the innovation. In particular, the evidence of this can be found in Seyfang & Smith (2007). And contemporary startup phenomenon is among the modern innovation drivers. The term "startup" stands for the newly created projects and companies that develop innovative products or services while looking for a cost-effective, reproducible and scalable business model to become a viable and successful organization. This point of view is shared by Thiel and Masters (2014), Romans (2013), Blank and Dorf (2012), Ries (2011). The startup is a complex system with a great number of interrelationships and thus, in many cases, the key to its success is in the multidisciplinary approach application.

The analysis of the projects has shown that currently, a new trend in the startup industry is focused on the sustainability problem-solving – a lot of projects are related to the development of the eco-friendly and human-oriented urban ecosystems, providing high-quality education or designing high-tech solutions that will help people live longer and be healthier. There are startup schools, incubators, accelerators, etc. aimed at developing sustainable projects – for example, YSI (Young Sustainable Impact) international initiative which unites, trains and supports young people in order to produce solutions for the UN sustainable development goals (www.ysiglobal.com). Creation of such startups requires consideration of a large number of factors and evolution scenarios and is always characterized by high levels of uncertainty and risks.

In addition, startup development requires significant financial investments from business angels, venture investors, crowdfunding platforms, incubators, accelerators etc., as well as time, passion, knowledge and experience of the creators of the project with various scientific and cultural backgrounds. The evidence of this can be found in the papers of Lerner, Schoar, Sokolinski, and Wilson (2018), Köhn (2018), Zhang et al. (2017). Therefore, both startup founders and investors need an effective tool to assess the viability of the potential startup-projects and mathematical modeling methods, in particular, Bayesian networks are among the most relevant instruments for that.

Bayesian networks belong to the intellectual data analysis methods and can be used to determine regularities between them (Zgurovskiy, Bidyuk &

Terent'ev, 2008). Bayesian network is a probabilistic graphic model, presented by the directed acyclic graphs whose nodes are represented by specific variables while arcs between them are the conditional relationships between these variables. One of the main advantages of Bayesian networks is the ability to visualize the relations between the model components (Toropova, 2016). Because of the visualization, the creation of such models helps determine factors that affect the startup development process, identify relationships between them and analyze the ways to influence these factors in order to achieve the desired evolution scenario. Bayesian networks provide an opportunity not only to evaluate startups but also to increase the project management effectiveness. Thus, the usage of probabilistic graphic models is a promising direction for analyzing the success of innovative startups in order to make solid management decisions.

Analysis of the literature sources and problem statement

Currently, a lot of scientific papers are devoted to the study of the features of innovative projects, many researchers try to figure out how this phenomenon affects the development of specific countries and the world as a whole and also try to determine the factors that influence startup success. They apply both qualitative and quantitative methods and mathematical modeling is one of the key tools in their investigations. The conducted literature sources analysis has shown that startups as a phenomenon are based not only on the economic but also on the social and cultural processes and background including team peculiarities, the innovative climate in the country, infrastructure availability, etc.

For example, Ouimet and Zarutskie (2014) focus on the relationships between employee age, firm age and growth and considers how the supply of young workers is related to the startup creation in high-tech industries. The authors pay attention to the fact that startups disproportionately hire young workers, giving them higher wages, than older firms. In Kaiser and Müller (2015) startup teams were studied in terms of skills and professional characteristics of the team members with the aim to determine facts concerning the startup team member diversity and the patterns of its evolution over time. The research conducted by Gundolf, Gast, and Géraudel

(2017) was aimed at exploring the ways of how entrepreneurial motivations influence the diversified innovation behaviors in the startup-projects and it was found that various startup motivations have different impacts on the diverse innovations development.

Many papers are devoted to the social impacts of startups and various aspects of their collaboration with governmental and commercial structures, especially educational. For example, in Davila, Foster, He, and Shimizu, (2015) the influence of the early-stage company sector on revenues and jobs was investigated, while the study of the Kohler (2016) was devoted to the developing relationships between startup-projects and corporations and considers various factors that can influence this process. In the article of Lacerda, Klein, Fulco, Santos, and Bittarello (2017) an approach for integration between universities and startups through the scientific and applied knowledge generation and propagation was proposed. The research represents the way for an innovative integration between universities and incubated companies and proposes a unique decision model for entrepreneurs. In turn, Pangarkar and Wu (2013) have analyzed the peculiarities of the alliances' formation, the characteristics of partners, the relationships between the strategies of alliances and the performance of high-tech startups. It was proved that projects that develop more strong alliances with partners have better performance and are more successful.
Authors in various fields of science consider startup success from different points of view. For instance, the article by Vieira, Prado, Alcântara, and Bermejo (2015) is focused on the description and analysis of the open innovations challenges in technological startups, as well as the determination of the restrictive and reinforcing factors that influence high-tech projects. In Klabunde (2016) the issue of trust between a startup entrepreneur and an investor was considered and it was substantiated that trust is an essential determinant for startup financing and success. Very often the "lean startup" concept is applied. In particular, in Rasmussen and Tanev (2015) innovative networks, international entrepreneurship and early internationalization are considered in the framework of the lean global startups as a unique new type of a company.

In the study of Wallin, Still and Henttonen, (2016), devoted to the investigation of the ambitions and goals of Finnish startups in the context of entrepreneurial growth, it was noted that technological startup-projects can become the main driving force for the economic growth in Europe. The researchers concluded that startup position on the market, the perspective of business scaling, personal characteristics and experience of teams, as well as barriers and limitations in the areas of projects implementation are extremely important for success. At the same time, startups have different growth patterns – while the success of one project may depend on the developers' talent, the success of the others can be specified by the well-established international sales networks.

The research of Čirjevskis and Dvotsova (2012) was aimed at the identifying the most important qualitative criteria for the innovative startups evaluation and also at the creation of the mathematical probabilistic model for the innovative business success prediction. The expediency of investing in startup-projects was also considered. Researchers focused attention on the startup processes and phenomena which are related to the managerial decisions, risks, demand, competitiveness, experience, products, strategies and business sustainability. At the same time, the study of Allen, Gloor, Fronzetti Colladon, Woerner and Raz (2016) was devoted to the evaluation of the innovative capabilities of biotechnology startup-projects in relation to the geographic nearness and knowledge sharing in the R&D networks. The authors determined that location influences the communication between companies, but does not influence the innovation success, while the more dynamic style of communication, as well as diverse social ties, can be beneficial for the innovations.

So, the issue of the startup success evaluation is very important but currently it is not completely solved and requires further development, especially in terms of the creation of accurate and clear mathematical models. And we consider Bayesian networks as an effective and reliable instrument for this purpose because they have been already successfully used in economics, medicine, ecology, electronics, etc. In particular, they were used for credit risks assessment (Leong, 2016) and in the marketing sphere (Reyes-Castro & Abad, 2016); for modeling processes that occur in the environment (Aguilera, Fernández, Fernández, Rumí & Salmerón, 2011); cyber security analysis (Peng, Li, Xinming, Peng & Levy, 2010); for the evaluation of risks arising during the software projects implementation (Hu, Zhang, Ngai, Cai & Liu, 2013), etc.

The results of the research and their discussion

The aim of the research is to identify the key startup success factors and to develop an instrument for startup success evaluation in order to minimize the loss of time and resources and partly overcome the high uncertainty rates, specific to the startup industry, using multidisciplinary approach and, in turn, contribute to the sustainable development implementation.

Thus, the study consists of two key parts. The first one was devoted to the identification of the factors which influence the success of the innovative startup-projects and to the determination of the criteria for the startup evaluation. Both factors and criteria have been selected in accordance with the principles of measurability, specificity and relevance by analyzing existing scientific investigations, startup projects data and by systematizing the authors' experience of working with startups. In order to assess startups on the bases of the proposed criteria, the data about projects was obtained from their official websites and social media profiles, crowdfunding platforms (Kickstarter and Indiegogo), Crunchbase, Startup Ranking, etc. Then these data were processed in R Studio by the algorithm provided in the corresponding section of the paper. The second part of the research was devoted to the development of the Bayesian network model for prediction of the startup-projects success depending on the combinations of the conditions on various markets, regions, etc.

Analyses of the factors which influence the success of the innovative startup-projects and determination of the criteria for their evaluation

The conducted analysis has shown that there are three key constituents which influence startup success – an external environment (designated in the mathematical model as "Env"), startup activity (Act) and an internal environment of the startup-project (StEn). These constituents partly correspond to the structure for venture projects evaluation firstly proposed by Gartner (1985) and described in van Gelderen, Thurik and Bosma (2006),

which originally contained the following four components – individuals, organization, process and environment. So, in order to assess each of them and establish the relationships between nodes, the discovered factors were divided into three groups according to their influence on these constituents.
Both in the developed startup success model and during startup-projects data processing the *external environment* was assessed as favorable, neutral or unfavorable. The environment is determined by business climate (BCl), legislation peculiarities (Lgsl), competitive environment (Comp), customers (Cus), suppliers (Sup), production facilities availability (PrF), partners (Part) and technological mode (TM). Business climate was considered as stimulating or slowing for the startup development; legislation – as adapted for the innovative companies or inconsistent. The competitive environment was rated as "Comp_Yes" if the competitors with significant opportunities already exist on the market or "Comp_No" if the number of competitors is small, their capabilities are limited or they are absent. An entry "Customers_Yes" corresponds to the case when there is a sufficient number of customers to obtain permanent income; "Customers_F" – when there are only first consumers; "Customers_No" – when the number of consumers is very small or they are absent at all.

An interaction with suppliers was taken into account as "Suppliers_Yes" if collaboration with suppliers is established; "Suppliers_T" if there are only temporary suppliers; "Suppliers_No" if it is difficult to find suppliers of raw materials, components, equipment, etc. which are essential for the product development or if cooperation is not established currently. Production facilities availability was considered under three scenarios: there are vacant or easy-to-access production facilities that can be used without significant investments (PF_Vacant); a project does not require significant production capacity up to the business scaling stage, since it can create prototypes and minimum viable products (MVPs) on a 3D printer, it is an IT startup and develops a software product or service, etc. (PF_Yes); all production capacities have been already occupied or it is necessary to make considerable investments (PF_No). If beneficial partnerships are arranged the label "Partners_Yes" was designated in the model; if partners are absent or partnerships are unprofitable the label "Partners_No" was designated.

Technological modes are also among the most important determinants of the external environment. It was found that the emergence of the startup phenomenon, as well as venture business at all, is directly related to the change of technological modes. The concept of technological modes is based on the Kondratiev large cycles theory. According to this concept, at each stage of the economic development the productive forces are based on an integrated coherent set of technologies that form a closed sustainable system represented by technological modes. In this case, the process of the world development is considered as a progressive sequence of changing technological modes that correspond to the large cycles. Significant changes in the society and economy occur at the beginning of each large cycle through the implementation of scientific and high-tech innovations of the more progressive technological mode. The life cycle of the technological mode covers nearly a century and it dominates in the economic development for nearly forty years but these periods are gradually reducing (Glaz'ev, 2012; Popov, 2011). It was also found that in the era of the technological mode changing, the strategic window for breakthrough startups development is opening because during this period of a high uncertainty the emergence of breakthrough innovations opens up new possibilities, markets, distribution channels, etc.

Thus, the three key technological mode eras were considered during startup-projects data analysis and then included to the startup success model – when the predominant technological mode is at the peak of a widespread phase while the new one has not appeared yet (TechMode_1); the new mode only starts emerging, while the previous one finishes the growth phase (TechMode_2); the era of technological mode change, when the previous mode finished the rapid growth phase and the new one has completely emerged (TM_Change).

The next constituent, *startup activity*, was considered as effective or inefficient. It is determined by startup strategy based on the 4P marketing mix concept – product (Prod), price (Pr), place (Pl) and promotion (Prom); as well as by the support of venture investors, business angels, startup-schools, incubators, accelerators, science parks, etc. (Sprt); involvement in the special startup events and platforms (Inv); product development (PrDv). Product, price, place and promotion strategies were taken into account as well-thought-out and developed on the basis of a solid marketing analysis (designated as Prod_WTO, Pr_WTO, Pl_WTO and Prom_WTO respectively) or insufficiently thought out and based on untested hypotheses (Prod_ITO, Pr_ITO, Pl_ITO and Prom_ITO respectively). The support was evaluated as "Support_Yes" if there is a financial, resource, infrastructure, mentoring, etc. support; as "Support_Exp" if support is expected; or as "Support_No" if there is no support at all. If startup project actively take part in startup events it was indicated as "Involve_Yes", while if not – as "Involve_No". According to the model, the product development progress was considered as "MVPinDev" if MVP is not created; "MVP_Dvlpd" if it is created; "ComplProd" if the complete product or service is ready.

At the same time, the *internal startup environment* was considered in two ways. As a reliable which facilitates startup development and strengthens its positions on the market. In this case, the components of the internal environment are balanced, while the startup goals are based on the SMART concept and substantiated hypotheses. And as an unreliable if the current environment is harmful to the startup project development and thus needs to be changed in order to achieve greater efficiency. In the developed model the internal startup environment is determined by innovation level (InLv), leadership style (LdSt), scalability (Sc), current financial indicators (FnIn), education level of team members (Ed) and team structure (TStr). The innovation level of the project idea corresponds to the framework described by Henderson and Clark (1990), according to which there are four levels – from incremental (Inc_In), which is easy to implement, to modular (Mod_In) and architectural (Arch_In), which have an average complexity of technological implementation and finally to radical (Rad_In) with an extremely high complexity of implementation.

The leadership style was determined in accordance with Burke and colleagues (2006) as person- (Person-F) or task-focused (Task-F). In terms of scalability, startups were considered as scalable or non-scalable, while their financial indicators as optimistic or pessimistic. The education level of team members was taken into account as only school-level or school learners (School), higher education (H_Education) or university students (Univ_Std). The team structure was considered as qualified and balanced (QBalanced) which consists of professionals of different specialties (programmers, engineers, marketers, managers, etc.); qualified and unbalanced (QUnbalanced) if there are no specialists in some spheres; untrained.

These three constituents affect the startup success (StS) and in a result the Bayesian network model visualize the probability distribution between the high (High_SL), average (Average_SL) and low (Low_SL) success levels. During startup data analysis success of the projects was also considered as high, average or low.

Development of the Bayesian network model for startup success evaluation

The components of the methods described in Scutari and Denis (2015), Nagarajan, Scutari and Lèbre (2013) and Sarkar (2008), were used in the research to develop Bayesian networks, make calculations and visualization. R and R Studio software with specialized packages Bnlearn, Rgraphviz, gRain, Lattice, etc. have been used for the modeling purposes. The structure of the Bayesian network was composed on the bases of the determined success factors. The model development process is shown in Figure 1. At the first stage the Bnlearn package designed specifically for the interaction with Bayesian networks was attached and an empty network with a set of unconnected nodes was created. As can be seen from the Figure 1, the object "Startup" of the "bn" class was produced. "Bn" objects are the basis for the modeling by Bnlearn in R Studio.

The next stage was devoted to the creation of the Bayesian network structure by setting arcs between the nodes. Interconnections were set in a form of a matrix with two columns, specifying the direction. Each line in the section "arc.set" in Figure 1 describes one arc which connects two nodes. For example, the entry «[3,] "FnIn" "StEn"» means that connection between the node "current financial indicators" directed to the node "internal startup environment" was set. After that, the determined structure was assigned to the "Startup" object specified at the first stage. Then for the visualization of the created directed acyclic graph the Rgraphviz package was used. The obtained Bayesian network which consists of 25 nodes and 24 arcs is presented in Figure 2. This network corresponds to the following model:

[PrDv][Prod][Pr][Pl][Prom][BCl][Lgsl][InLv][Sc][FnIn][TStr][Ed][Comp][Cus][Sup][PrF][Part][TM][Sprt][Inv][LdSt][StEn|InLv:Sc:FnIn:TStr:Ed:LdSt][Env|BCl:Lgsl:Comp:Cus:Sup:PrF:Part:TM][Act|PrDv:Prod:Pr:Pl:Prom:Sprt:Inv][StS|StEn:Env:Act]

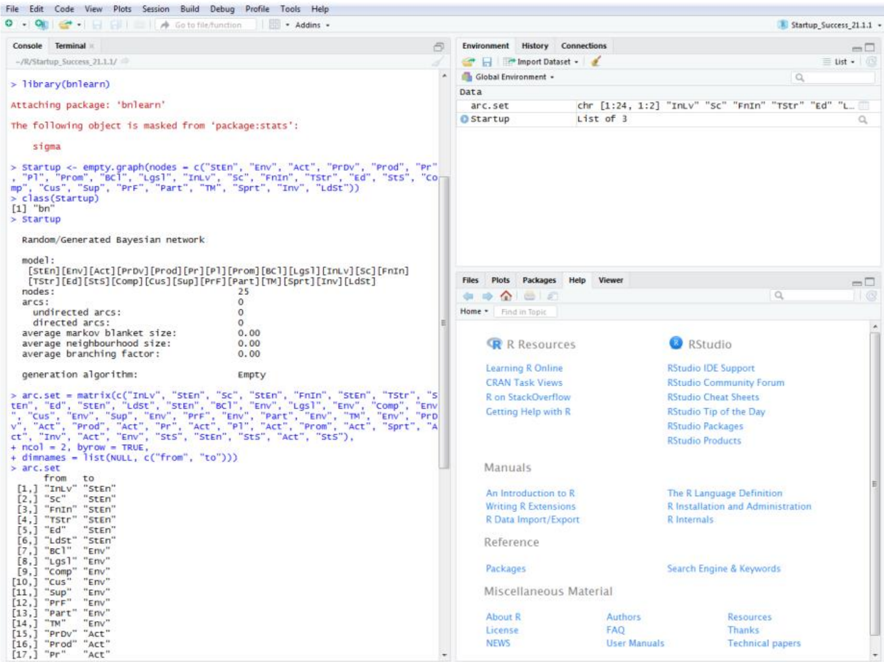

Figure 1. Development of the Bayesian network in R Studio for the startup success evaluation

After obtaining the model and the structure shown in Figure 2, for a quantitative assessment of the startup success and calculation of the probability distributions for the Bayesian network, a sample with data for innovative startup-projects was analyzed. The data analysis was carried out in accordance with the factors and criteria set out at the first part of the investigation.

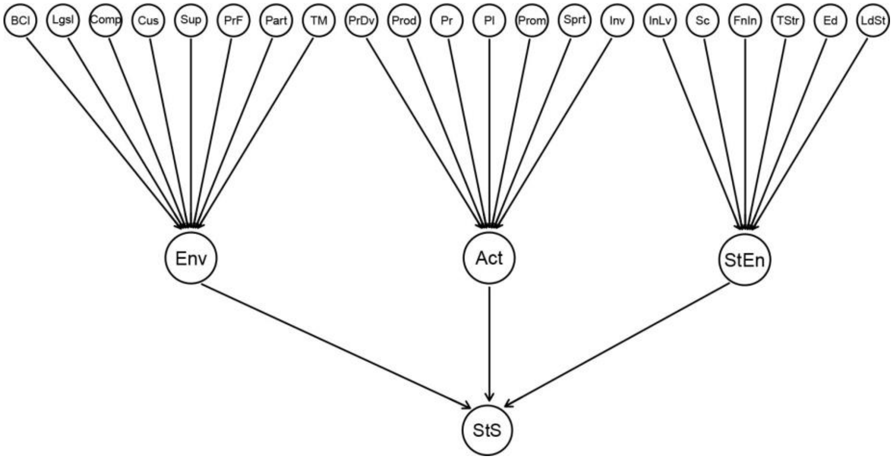

Figure 2. The result of the Bayesian network graphic modeling for startup success evaluation in R Studio

The data analysis results were summarized in a "table" structured according to the R Studio and Bnlearn requirements. After that, using the "read.table" function, these data have been connected to the model. As a result of data processing in the R Studio software environment, the "Startup.bayes" object of the "bn.fit" class was created by combining data with the network structure, shown in Figure 2. In this model conditional probabilities were evaluated in the "bayes" setting, using the posterior distributions, since according to Scutari and Denis (2015) a posterior assessment leads to an increased accuracy of the Bayesian networks forecasts.

Then, by Rgraphviz, gRain, BiocGenerics, Graph and other packages the plots with probability distributions for the "Startup.bayes" object were calculated and visualized. The Bayesian network with calculated probabilities was divided into four parts for the convenience of results analyzing. The first part corresponds to the external environment assessment. The calculation results for the *external environment* estimation are shown in Figure 3. It was found that the probability of the fact that the business climate will be stimulating is 59.1 %, that the legislation will be adapted is 68.2 %, that the competitors will be absent is 48.2 % and that the partners will be present is 40.0 %. In addition, with a probability of 30.3 %, there will be constant customers, while with a probability of 54.8 % there will be only the first clients. The probability of gaining at least temporary suppliers is 61.2 %, while vacant production facilities are likely to be in 19.4 % of cases.

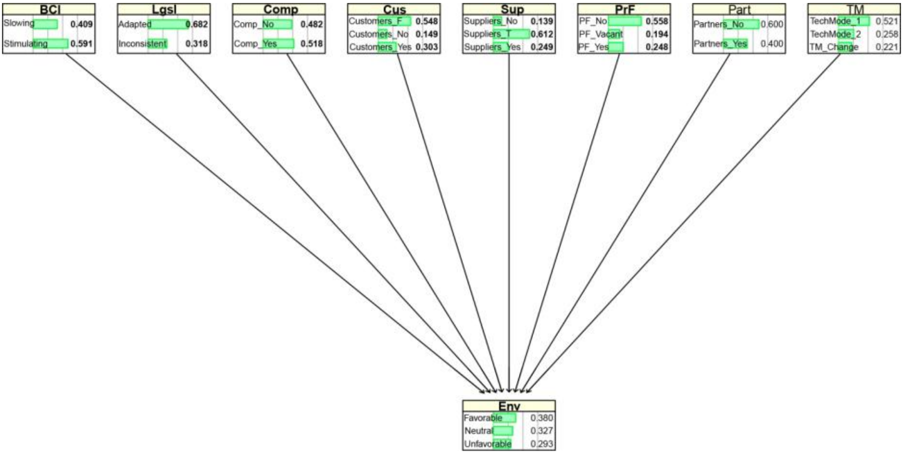

Figure 3. The probability distribution for the assessment of the external environment influencing the startup-projects development

In addition, most often the situation when the predominant technological mode is at the peak of a widespread phase while the new one has not appeared yet can be observed (52.1 %). The case when the new technological mode only starts emerging, while the previous one finishes the growth phase is on the second place with 25.8 %. And the era of technological mode change, which is the most favorable for the breakthrough radical innovations creation, is on the third place with 22.1 %. The influence of all the components mentioned above results in the following distribution of the expected probabilities for the external environment node: favorable – 38.0 %; neutral – 32.7 %; unfavorable – 29.3 %.

The results of the *startup activity* modeling are shown in Figure 4. It has been established that the product strategy is well-thought-out with a probability of 51.8 %, while price, place and promotion strategies – with a probability of 40,0 %, 48,2 % and 29,1 % respectively. It was discovered that in most cases teams take an active part in various startup events and platforms (63.6 %). Projects receive support in 33.0 % of cases and in 24.0 % they expect it in the nearest future. In addition, the probability distribution in terms of the product creation is as follows: 30.3 % – a complete product exists; 39.4 % – MVP was developed; 30.3 % – MVP in development. Taking into account all these data, the following modeled distribution of probabilities for the startup activity was obtained – with a probability of 44.5 % the activity can be effective, while with a probability of 55.5 % it is more likely that it will be inefficient.

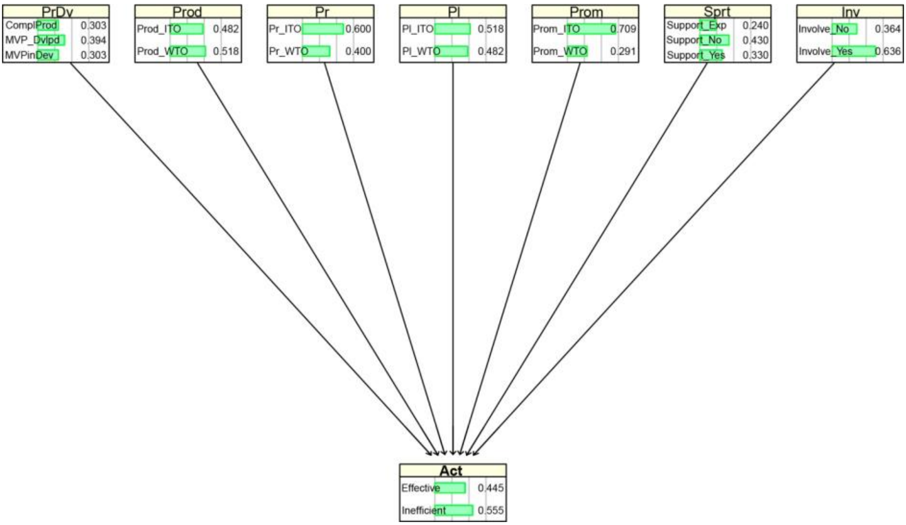

Figure 4. The obtained probability distribution for the startup activity assessment

The next component is the *internal startup environment*. According to the Figure 5, both in the case of scalability and current financial indicators, the probabilities were distributed approximately equally. However, scalable startups are dominating (52.7 %), as well as optimistic financial indicators (50.9%). Person-focused style prevails among leadership styles (60.0 %). In terms of education teams are mainly built of university students (45.8 %) or people with higher education (41.2 %) and they are often qualified and balanced (53.0 %).

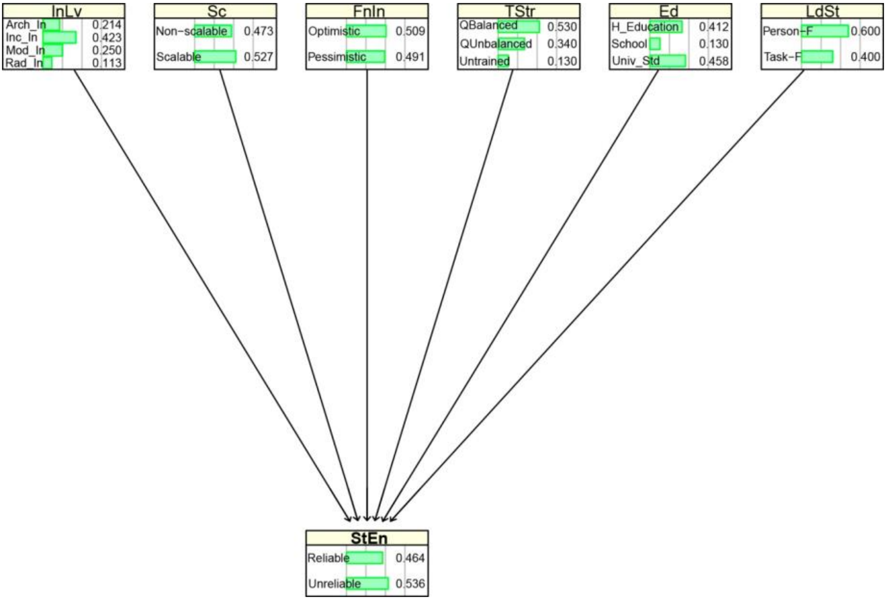

Figure 5. Probabilities distribution for the internal startup environment estimation

Among the innovation levels of startup-forming technologies, an incremental prevails with 42.3 %. The number of architectural and modular innovations has been distributed approximately equally – 21.4 % and 25.0 % respectively, while the number of radical innovations is 11.3 %. The mathematical modeling of the internal startup environment reliability was conducted taking into account the data from all influencing factors in accordance with the Bayesian network structure, presented in Figure 2. And it was predicted that the internal environment can be reliable with a probability of 46.4 %, that is a quite good result.

As can be seen from Figure 6, the *success of startup-projects* depends on the modeling results presented in Figures 3–5 because all of them influence the final result. Consequently, taking into account the favorableness of the external environment, the startup activity efficiency and the reliability of an internal environment, the modeled startup success probability is most likely to be of a low (43.9 %) or an average (41.4 %) level. The probability of a high success level is only 14.7 %.

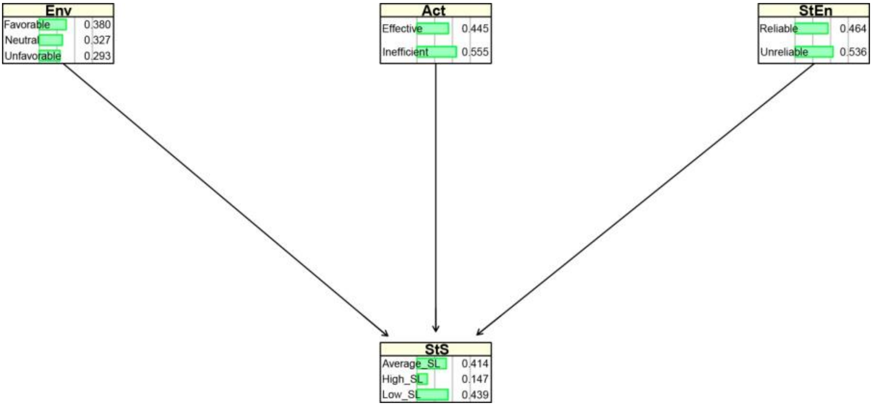

Figure 6. The modeled probabilities distribution for the evaluation of the levels of startup success

One of the advantages of the developed model is that it can be used to analyze various combinations of conditional probabilities in order to investigate the interactions between components influencing the startup success levels. The visualization was performed by the "bn.fit.barchart" command and a special R Studio package Lattice, that is used to work with graphics.

The *conditional probabilities distribution* for the *startup success* estimation is shown in Figure 7. Unlike the results presented in Figure 6, in this case there is a possibility to clearly investigate the influence of different conditions on the success of the projects. It was found that startups which are created in the favorable external environment, with reliable internal environment and effective activities are the most successful ones, which is quite obvious. The more important is the determination of the combinations of conditions in which startup performance will still be at the acceptable level and also the specification of the most harmful combinations.

So, as can be seen from the Figure 7, in the cases when internal startup environment is unreliable but external environment is favorable or neutral and the activity is effective; as well as when only startup activity is inefficient but external environment is favorable or neutral and an internal environment is reliable, the average level of success prevails with the probability of more than 80 %, while the probability of high or low success levels is less than 10 % for each.

In the case when the external environment is neutral and other constituents are effective and reliable, the probability of an average success level is almost 70 %, high level – above 20 %, and low level – below 10 %. When an internal environment is reliable and startup activity is effective but an external environment is unfavorable, the probability of the average success level is also near 70 %, but the likelihood of low or high levels is about 15 % for each.

The opposite situation is observed when the startup activity is effective, but external and internal environment are unfavorable and unreliable respectively – with the probability of almost 70 % the startup success levels will be low, while the probability of average or high success levels will be only 15 % for each. In addition, with a probability of more than 90 %, the low success levels can be observed when inefficient startup activity and unreliable internal environment are combined, as well as when inefficient activity is combined with the unfavorable external environment, even if the internal one is reliable.

So, it was determined that very high startup success levels can be observed only when all three constituents are favorable, effective and reliable, while in any other combinations the probability of the high levels does not exceed 30 %. There are six combinations in which startups can achieve average success levels, but at the same time there are five other combinations which correspond to the low success levels. It was found, that in combinations, in which only one option is negative, the average success levels are dominating, while the probability of high and low success levels is divided approximately equally.

At the same time, as can be seen from the Figure 7, the greatest probability of failure can be observed in the unfavorable external environment, while the smallest – in the case of the inefficient startup activity. Thus, the favorableness of the external environment is one of the critical success factors. Even when it changes from favorable to neutral, the likelihood of high success levels decreases from over 90 % to less than 30 %. In particular, such probability distribution can be explained by the fact that it is easier to adjust internal processes and activities than to change the external environment. For example, the startup team can improve its marketing strategy, begin to take an active part in specialized events, invite additional experts or mentors, attract venture investments and so on. In the cases of combinations in which two of the three components are negative, low success levels prevail. In this case, the most critical situation can be observed when unreliable internal environment and inefficient startup activity are observed simultaneously.

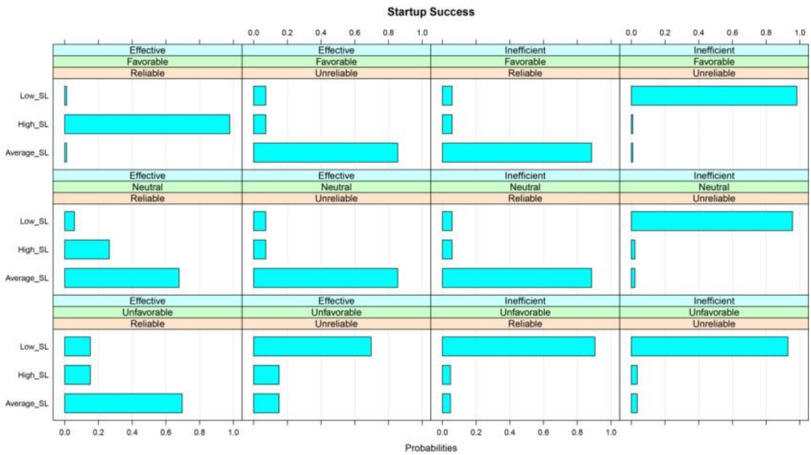

Figure 7. The conditional probabilities distribution for the assessment of the startup-projects success

Conclusions

In the conducted investigation the factors which influence the success of innovative startups were identified and substantiated. It was determined that there are three main constituents which influence the success of the projects – an external environment, startup activity and an internal startup environment. Thus, the determined factors were analyzed according to the groups which correspond to these constituents. The mathematical model in the form of the Bayesian network for evaluation and prediction of the startup success was developed. The estimation of the external environment by this model has shown that the probability of the fact that it will be favorable is 38.0 %; neutral – 32.7 %; unfavorable – 29.3 %. At the same time, the startup activity can be effective with a probability of 44.5 %, while the internal environment can be reliable with a probability of 46.4 %. Taking into account the probabilities obtained for the components of the Bayesian network model, it was found that the modeled startup success probability is most likely to be of a low or an average level with probabilities of 43.9 % and 41.4 % respectively, while the probability of a high success level is only 14.7 %. The conditional probabilities distribution for the startup success estimation was also analyzed and the combinations of conditions in which startup performance can be at the acceptable or unacceptable level were determined.

The developed Bayesian network model can be used for the analysis of various innovative projects samples in order to determine the success levels of startups in a particular country, region, in a specific market, etc. This will contribute to the development of the effective marketing strategy and action plans for the innovative high-tech projects and will also increase the survival rates of startups. And this, in turn, can help to solve important social, economic and environmental issues. In particular, a trend of the creation of sustainable startups in such spheres as green economy development, 3D printing, alternative energy sources, water purification technologies and environmental safety is a solid confirmation of this.

The implementation of the proposed Bayesian network model can save resources and time of the startup founders and also money of the investors presenting them the potential success rates of the projects. Furthermore, both founders and investors can correct the trajectory of the development of a particular startup by analyzing combinations of conditions and choosing the most favorable ones in order to increase the success rates. In turn, reducing the number of unsuccessful projects can save the planet's resources. An important aspect of the startup development is the limited support which investors, incubators, accelerators, etc. can provide. At the same time, the data, obtained from the proposed model, can be especially valuable for initiatives aimed at supporting the sustainable-oriented projects, because despite the fact that their numbers are gradually increasing, it is still not enough. So, the results of the investigation can contribute to the achievement of the UN sustainable development goals from the economic, ecological and social perspective.

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