VENTURE CAPITALISTS DECISION MAKING: APPLYING ANALYTIC NETWORK PROCESS TO THE STARTUPS EVALUATION

Maria Milkova
Central Institute of Economics and Mathematics
of the Russian Academy of Science
m.a.milkova@gmail.com

Olga Andreichikova
Central Institute of Economics and Mathematics
of the Russian Academy of Science
alexandrol@mail.ru

Alexander Andreichikov[1]
Central Institute of Economics and Mathematics
of the Russian Academy of Science
andreichickov@mail.ru

ABSTRACT

The idea of synthesizing analytical and heuristic approaches is proposed in order to join different approaches to the Venture Capitalists (VCs) decision making. The research applies Analytic Network Process (ANP) methodology to the comparative evaluation of four e-commerce startups. The proposed ANP model represents the decision problem as a structure of Benefits-Opportunities and Risks networks with dependences and feedbacks between decision criteria and alternatives. Based on VCs judgments that are checked for consistency, the ANP approach helps choose the best startup for funding or to estimate the target startup versus other startups. The ratings that are obtained may be used as weights for determining a startups valuation. In the model, heuristics is used without reducing the complexity of the task and thus helps avoid the systematic error. Moreover, the idea of applying ANP to the VCs decision making serves to make the decision process transparent and understandable. To implement the ANP model, Multichoice software has been developed.

Keywords: venture capital; decision making; heuristics; Analytic Network Process; startups evaluation

[1] This work is supported by Russian Foundation of Humanities, project No. 16-02-00743 "Multi-criteria analysis and forecasting the techno-economic state and trends for leading aerospace companies"

1. Introduction

The startup market is highly competitive and the percentage of companies that prosper is small. In the early stage of development, startups often experience various difficulties including a financial gap that limits the company's ability to innovate and commercialize its products (Hudson & Khazragui, 2013). The success or failure of a new business is often dependent on overcoming a series of potential barriers, e.g. limited human capital management capabilities, high uncertainty in terms of product and market, volatile development process, weak partnership ties (Fielden, Davidson, & Makin, 2000).

There is enough research to support the idea that start-ups that are supported by Venture Capital (VC) generally tend to be more successful than those that do not receive VC support (Gompers & Lerner, 2004; Chemmanur, Krishnan & Nandy, 2008; Bertoni, Colombo & Grilli, 2011). Undoubtedly, Venture Capitalists (VCs) play the most crucial role in identifying and financing new and highly innovative firms (Monika & Sharma, 2015). Moreover, Savaneviciene, Venckuviene and Girdauskienea, (2015) conclude that VC is a catalyst for startups to overcome the "valley of death".

While some researchers suggest using statistics to make better VCs decisions, others mention the importance of intuition, arguing that most business decisions are made in the face of uncertainty and these uncertain situations have too many unknowns and complexities to lend themselves to statistical analysis (Miloud, Aspelund & Cabrol, 2012; Narayanasamy, Hashemoghli & Rashid, 2012; Mousavi & Gigerenze,r 2014). Zacharakis and Meyer (2000) suggest that although the expert VC's intuition is valuable it often leads to biased results.

In this article, in order to join different approaches to VCs decision making, we synthesize analytical and heuristic approaches through applying Analytic Network Process (ANP) methodology. An example of comparative evaluation of four Russian e-commerce startups is considered. The proposed ANP model represents problem complexity as a network structure with dependences and feedbacks between decision criteria and alternatives. Based on VCs judgments that are checked for consistency, the ANP approach helps choose the best startup for funding or estimate the target startup versus other startups. ANP makes it possible to make decisions under risks as it allows examining the problem from different angles, e.g. benefits, opportunities, and risks (Saaty, 2008a). To implement the ANP model Multichoice software has been developed.

2. Venture Capitalists decision making

In the area of VC investment decision methods are used both as tools to evaluate startups, and as tools to analyze in order to identify the factors that drive financial decisions. VCs decision criteria have faced numerous challenges with identifying the economic value of a new venture. A number of studies have produced empirically derived lists of the principle evaluation criteria. The earlier VC research mostly agreed on six criteria: management skill and experience, venture team, product attributes, market growth and size, and expected returns (Macmillan et al., 1987; Robinson, 1987; Hall and Hofer, 1993). Subsequent works have also acknowledged the importance of passion in entrepreneurship (Cardon et al., 2009).

ISSN 1936-6744
https://doi.org/10.13033/ijahp.v10i1.511

Initial research used post hoc surveys and interviews to collect data on VCs' self-reported decision policy for decisions made in the past. This reliance on retrospective and self-reported data may have generated biased results. Zacharakis and Meyer (1998) support the fact that people are poor at introspection and often suffer from recall and post-hoc rationalization biases among others. Therefore, real-time methods such as Verbal Protocols and Conjoint Analysis are more appropriate and eliminate these biases.

Verbal Protocols are real-time "think aloud" observations of VCs screening a potential deal (Landström et al., 2007). Different research studies have used Verbal Protocols to understand information in the actual decision process (Hall & Hofer, 1993; Zacharakis & Meyer, 1995).

Conjoint Analysis is a technique that assesses decision criteria (attributes) and their significance in the judgment, and how these attributes affect the judgment and the relative importance of each attribute in the decision process (Shepherd & Zacharakis, 1999). Conjoint Analysis has been used in many studies and gains a deeper understanding of the VC decision process (Hsu, et al., 2014; Zacharakis & Shepherd, 2005).

Another attempt at accomplishing some improvement in the VCs decision process was proposed by Zacharakis and Meyer (2000). They introduced actuarial decision aides that are models that decompose a decision into component cues and recombine those cues to predict the potential outcome. Actuarial models include environmental and bootstrapping models, where the former employ discriminant or regression analysis on actual decision data. Shepherd and Zacharakis (2002) proposed that bootstrapping models hold considerable potential for improving VCs decision accuracy.

In any case, for evaluating new ventures not all the VCs are able to follow the same investment decision process (Monika & Sharma, 2015). VCs are individuals with their own unique experience, perspective and business priorities, so they do not evaluate startups the same way. Some VCs give more importance to the entrepreneur's characteristics, while others are more intrigued with financial and marketing perspectives. Monika and Sharma (2015) highlight that VCs follow the multi-criteria perspective for taking investment decision.

2.1 Using heuristics

It is well recognized in the decision-making literature that decision makers are not perfectly rational, but "boundedly rational", which means that when individuals make decisions, their rationality is limited by the tractability of the decision problem, the cognitive limitations of their minds, and the time available to make the decision (Simon, 1957). Tversky and Kahneman (1974) showed that people making decisions under uncertainty rely on a limited number of heuristic principles, which leads to systematic errors.

Zacharakis and Meyer (2000) suggest that a VC is apt to assess the success of a current venture prospect by how similar it is to a past success when analyzing VCs decision making. In this assessment, VCs use a representativeness heuristic, which may lead to severe errors (Tversky & Kahneman, 1974). Likewise, if a VC utilizes a satisfying heuristic it may eliminate potentially profitable investments (Zacharakis & Meyer, 2000).

ISSN 1936-6744
https://doi.org/10.13033/ijahp.v10i1.511

While assessing decision criteria, VCs may tend to underweight the more important criteria and overweight the less important criteria (Zacharakis & Meyer, 1998).

Thus, biases and heuristics significantly affect the behavior of VCs. Bias factors include risk perception, overconfidence, inconsistency and habit and framing (Dimov et al., 2007; Mitteness et al., 2012, Zacharakis & Shepherd, 2001). All considerations about applying heuristic rules and intuition in VCs decision making imply simplification of the decision process and inconsistent of human judgments.

Woike, Hoffrage, and Petty (2015) compared simple heuristics with machine learning and regression models and showed that simple heuristics is competitive with more complex VCs decision strategies. However, is it possible to synthesize analytic and heuristic approaches? Could we apply heuristics without sufficient reduction of the complexity of the problem? This article contributes to answering these questions.

2.2 Multi-criteria decision analysis

Due to the complex nature of VCs decision, we suggest that multi-criteria decision analysis (MCDA) methods can help find the best investment strategy. MCDA is devoted to supporting and aiding VCs in situations in which multiple conflicting decision factors (objectives, goals, criteria, etc.) must be considered simultaneously.

There is a vast body of literature on the use of multi-criteria methodologies in financial decision-making, such as project financing, financial performance evaluation, investment selection, extension of credit, and foreign direct investment; however much less is reported on applications of MCDA to VC portfolio selection (Beshah & Kitaw, 2013; Bhandari & Nakarmi, 2016; Saracoglu, 2015; Beim & Lévesque, 2004) . In recent research, Pakizeh and Hosseini (2015) propose PROMETHEE method; Afful-Dadzie, Oplatková, and Nabareseh (2015) apply Fuzzy PROMETHEE for selecting startup businesses; Beim and Lévesque (2004) consider MAVT. Lu and Shen (2011), Su, Jiang, and Ma (2009) and Gui-lan (2011) evaluate investment risks of VC company based on Analytic Hierarchy Process (AHP). Shijian and Yinyan (2015) apply AHP-Fuzzy evaluation methods to evaluate VC project. Wiratno, Latiffianti, and Wirawan (2015) apply ANP for selection of business funding proposals.

2.3 Why ANP?

Among the existing methods, ANP is one that considers dependences between decisions criteria (Saaty, 1996). In light of research on MCDA in making VCs decisions, we consider ANP as a decision aid for VCs in understanding the complexities of the decisions they face.

Although AHP/ANP have been widely used in solving different decision problems, the application of AHP/ANP in the articles related to VC has been very few. However, over the past two decades much research has considered comparative analysis of Conjoint Analysis (CA) and AHP (Helm et. al., 2002; Helm et. al., 2004; Schol et. al., 2005; Meißner & Decker, 2009; Ijzerman et. al., 2010). Most of them reported that not only “both methods are equivalent with regard to convergent validity”, but also AHP is “the better choice for the special decision situation considered” (Meißner & Decker, 2009; Schol et. al., 2005). This is somewhat astonishing considering the similarity of AHP and

ISSN 1936-6744
https://doi.org/10.13033/ijahp.v10i1.511

CA approaches, and the fact that CA is quite popular for measuring VCs preferences, while ANP/AHP is not.

In order to increase the practical relevance of ANP in VCs decision making, we consider an example of evaluation of four e-commerce startups. Based on neuroeconomic results that people compare choices within a set rather than assigning separate utilities, the comparative method is appropriate for VCs decision-making (Camerer, Loewenstein, & Prelec, 2004). In a high-risk area such as VC financing, selecting the right candidate can be very challenging and complex since most of the criteria involved are subjective and hold uncertain data.

Due to lack of the quantitative information on a startup's activities and the high level of uncertainty, the appropriate method for VCs decision-making must be based on subjective judgments, which not only measure preferences, but also reflect knowledge about influences between decision criteria and the strengths with which these influences occur. Zacharakis and Shepherd (2004) showed that interactions between decision criteria affect VCs decision making, so it is the ANP model that may be applied at startups evaluation process.

Thus, the ANP approach is considered suitable for VCs decision making because, (1) the model allows including a mix of quantitative and qualitative (or only quantitative) factors and implies interconnections between decision criteria; (2) decision problem may be examined not only from the Benefits side, but also from the Opportunities and Risks sides; (3) the integrity of the measurement system is verified for consistency because of subjective of human judgments.

3. Model construction and results

3.1 ANP Model

The ANP model may be constructed after the screening stage of investment where the number of initially available alternatives has been reduced. In our study, four Russian e-commerce startups (let us identify them as A, B, C, and D) are subjected to deep analysis with ANP.

Startup A is a coffee service for drivers, a small chain of stores that offers snacks, tea and coffee to go. Drivers can make an order and pay in advance via a mobile app, and then just pick up in order to save time.

Startup B is a time bank, a reciprocity-based work trading system in which hours are used as currency. With time banking, a person with one skill set can bank and trade hours of work for equal hours of work in another skill set instead of paying or being paid for services.

Startup C is an organic food delivery online service. The service integrates products from different stores to help people buy any organic food without an extra charge for delivery from different shops.

Startup D is an online store for renting sporting goods and equipment (skiing, skates, snowboards, bicycles, etc.). The service allows people to rent goods for the whole season

ISSN 1936-6744
https://doi.org/10.13033/ijahp.v10i1.511

and thereby solves the problem of storing goods in the apartment at the time of the year when they are not being used.

In order to make a comprehensive decision, an investor should take into account the startups performance and development prospects, as well as current and expected risks.

The model included two network structures:

1. Benefits- Opportunities network- This combines all criteria of efficiency and potential of the startups. We consider Benefits and Opportunities within one network structure as benefits criteria have always had an impact on opportunities criteria.

2. Risks network- This includes the most important current and expected risk factors.

These network structures are combined in the control hierarchy for evaluating the networks contribution to the final decision. Each network contains selection criteria, relationship among criteria, and the submitted funding proposals.

Decision criteria of the networks were chosen based on Macmillan et al. (1987), Robinson (1987), Hall and Hofer (1993) and on criteria used in the most popular Russian startups competition – School of a Young Billionaire, organized by Forbes Russia Magazine (Forbes, 2017).

The network of Benefits-Opportunities (Figure 1) includes six decision clusters which include the following: Growth for the last year, Society, Team, Promotion, Prospects, Production. Each of the clusters has its own specified criteria (nodes).

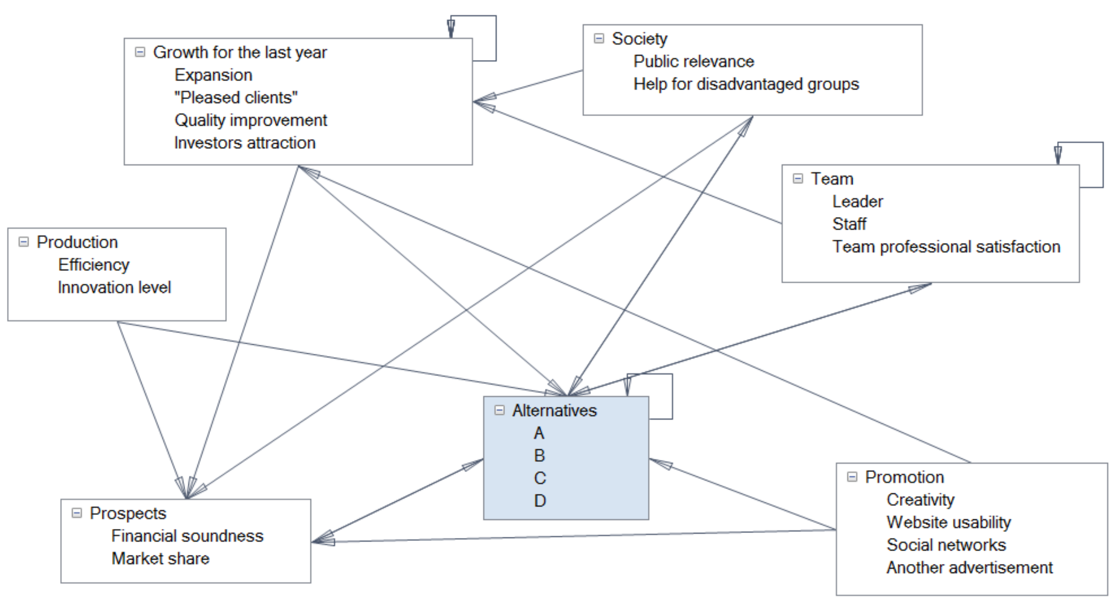

Figure 1 Benefits-Opportunities network

The network of Risks (Figure 2) includes four clusters which include the following: Competition, Commercial risks, Operational risks, and Other risks.

ISSN 1936-6744
https://doi.org/10.13033/ijahp.v10i1.511

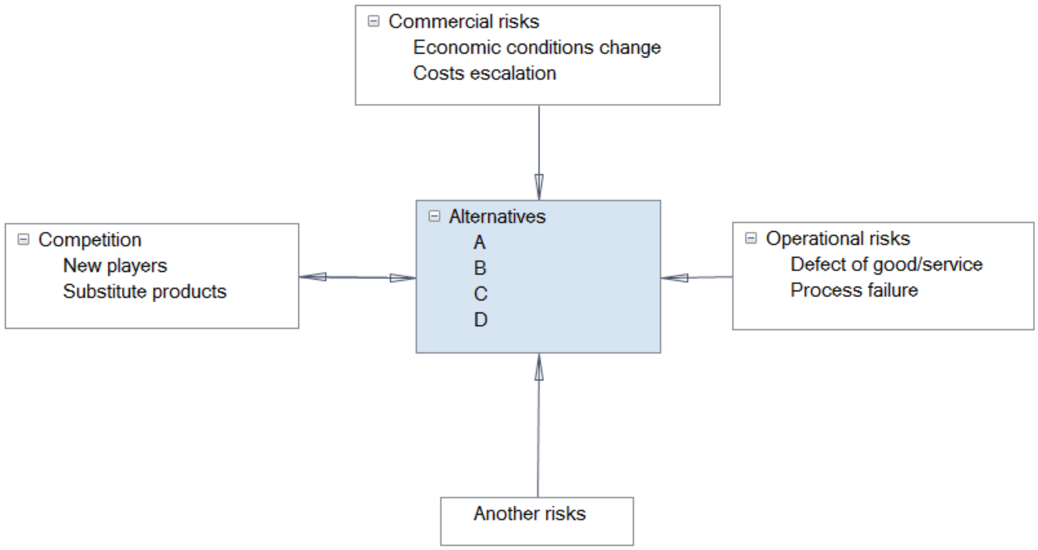

Figure 2 Risks network

To combine and evaluate a network's contribution to the final decision, the control hierarchy is built (Figure 3). Considered networks are evaluated in terms of the Company's profit, the Company's competitiveness, and Improving societal well-being.

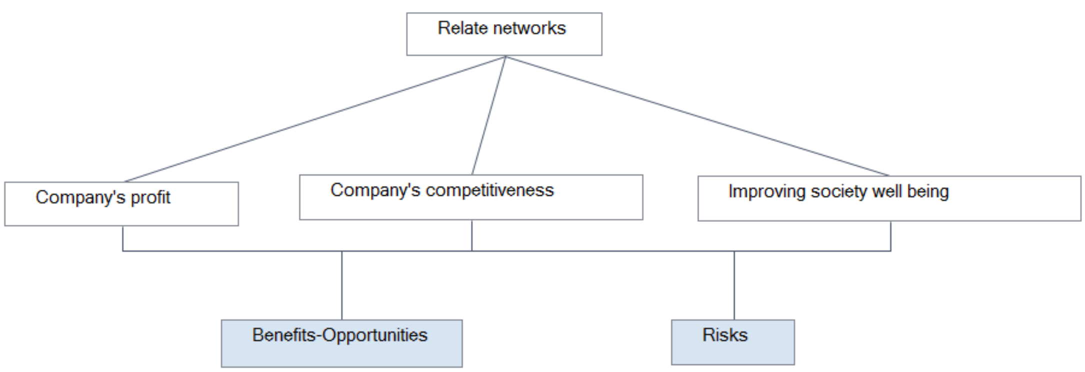

Figure 3 Control hierarchy

The result of the ANP algorithm is to find a startup with the highest ratings in terms of benefits-opportunities and risks priorities ratio. As a result, the selected startup will be the most attractive to receive funding.

3.2 Results

The model is built in Multichoice, which is a new software for MCDA based on the ANP/AHP (Milkova & Andreichikova, 2016). All pairwise comparison matrixes are filled by one expert, the investor concerned (for more details on the methodology of

ISSN 1936-6744
https://doi.org/10.13033/ijahp.v10i1.511

building pairwise comparisons see Saaty (2008b)). In this study, we do not consider the case of multiple experts, although this may be done (for more details see Saaty, 2010).

For the network of Benefits-Opportunities, thirty-seven pair comparison matrixes are filled: 6 for cluster comparisons, and 31 for nodes comparisons. The results of evaluating the startups by each decision criteria of Benefits-Opportunities network are shown in Figure 4.

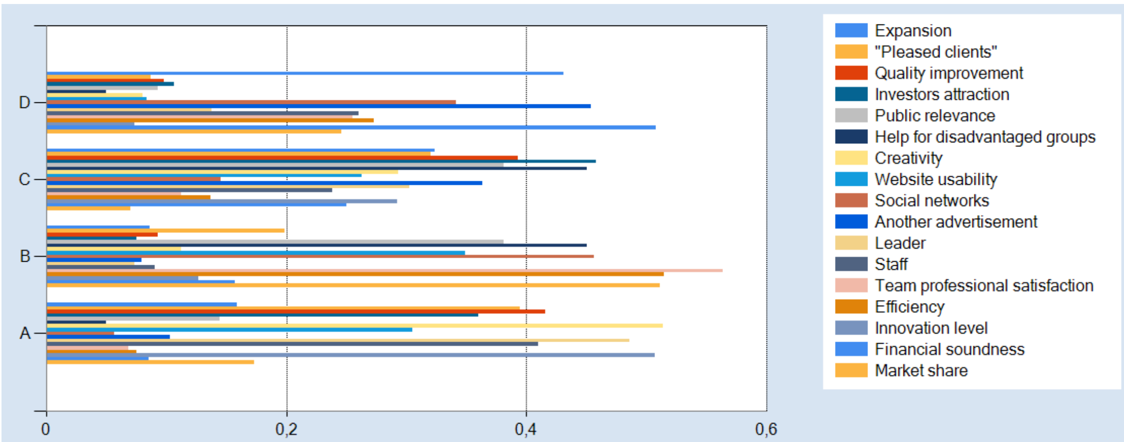

Figure 4 Results of pairwise comparisons of the startups by each node of the Benefits-Opportunities network

Further relative measurements of the influence of elements within the Risks network are considered. Eleven pair comparison matrixes for nodes are filled by the very same expert. The results of evaluating the startups by each decision criteria of the Risks network are shown in Figure 5.

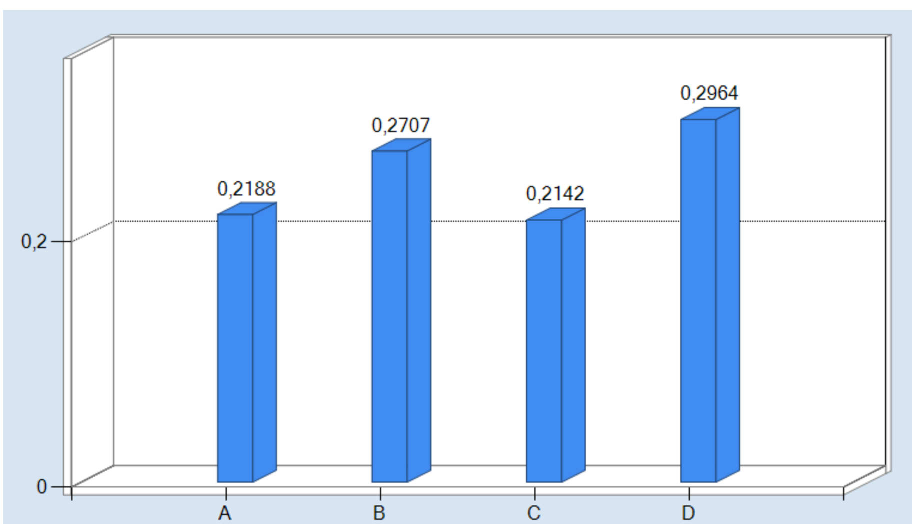

Figure 5 Results of pairwise comparisons of the startups by each node of the Risks network

ISSN 1936-6744
https://doi.org/10.13033/ijahp.v10i1.511

The priority vectors that are obtained are then combined in a supermatrix and weighted in a weighed supermatrix. After the limit supermatrix is calculated, cluster limit vectors are normalized.

Limit normalized by cluster priorities of startups in Benefits-Opportunities network is shown in Figure 6.

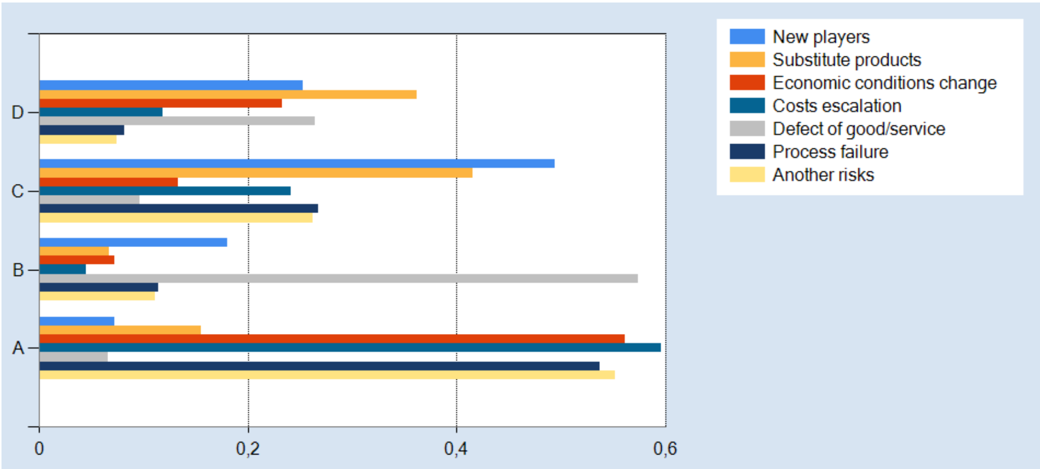

Figure 6 Limit normalized by cluster priorities of the startups in Benefits-Opportunities network

To analyze the obtained priorities of alternatives within the Benefits-Opportunities network (Figure 6), one should take into account that according to the network's structure (Figure 1) clusters Prospects, Growth for the last year and Team have the highest weights because they accumulate their significance through all links coming into them.

As shown in Figure 4, startup D has the highest node priorities of the "significant" clusters: Expansion (cluster Growth for the last year) – 0.43, Financial soundness (cluster Prospects) – 0.51. The B startup also has the highest node priorities of the "significant" clusters: Team professional satisfaction (cluster Team) – 0.56, Market share (cluster Prospects) – 0.51. Therefore, these startups are the best in terms of Benefits-Opportunities that is shown in Figure 6.

Limit normalized by cluster priorities of startups in the Risks network is shown in Figure 7.

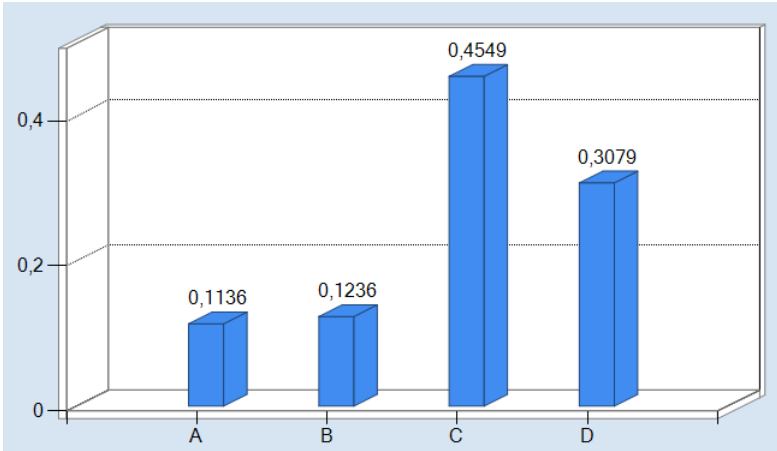

Figure 7 Limit normalized by cluster priorities of the startups in Risks network

One always should take into account a network's structure for analyzing the obtained priorities. According to the structure of the Risks network (Figure 2), only the Competition cluster accumulates the importance. Therefore, the priorities of the startups by nodes of the Competition cluster are more significant in making the final result. As shown in Figure 7, startup C has the highest priority (0.45) in the Risks network due to its highest nodes priorities of the "significant" cluster Competition.

To obtain priority ratings for the Benefits-Opportunities and Risks networks of the model, they are evaluated by selecting the appropriate rating category from a defined linguistic scale on each criterion of the control hierarchy. In the study, a "High", "Middle", and "Low" linguistic scale is used.

The results of networks linguistic evaluation in control hierarchy (Figure 3) are shown in Table 1.

Table 1
Linguistic estimation of networks by the criteria of control hierarchy

Criterion	Benefits-Opportunities	Risks
Company's profit	High	High
Company's competitiveness	High	Middle
Improving society well being	High	Low

Preferences for linguistic categories obtained by pairwise comparisons and equal:

ISSN 1936-6744
https://doi.org/10.13033/ijahp.v10i1.511

$w^{"HIGH"} = 0.56$, $w^{"MIDDLE"} = 0.32$, $w^{"LOW"} = 0.12$.

Priorities of the criteria of control hierarchy are obtained from pairwise comparisons and equal: $P^{"REVENUE"} = 0.1$, $P^{"COMPETITIVNESS"} = 0.23$, $P^{"WELLBEING"} = 0.67$.

Thus, the final weights of Benefits-Opportunities network (w^{BO}) and Risks network (w^{R}) are: $w^{BO} = 0.73, w^{R} = 0.27$.

The results of multiplicative and additive composition are shown in Table 2.

Table 2
Synthesis results

Alternatives	Benefits-Opportunities (0,7262)	Risks (0,2738)	Multiplicative	Additive
A	0,2188	0,1136	0,2658	0,2824
B	0,2707	0,1236	0,3031	0,3597
C	0,2142	0,4549	0,179	0,0685
D	0,2964	0,3079	0,2522	0,2894

According to the synthesis results, startup B seems to be the most attractive for funding. The startup is an example of a good balanced alternative that is placed second in terms of Benefits-Opportunities and Risks and first in overall ranking. All alternatives have positive priority at additive composition, which means that they carry benefits-opportunities higher than risks. Sensitivity analysis shows that the final startup's priorities are stable to the 5% changes of elements priorities in the networks and to the 5% changes of networks weights.

4. Discussion

4.1 Practical implementation issues

The goal of this paper is to improve VCs decision making by synthesizing analytical and heuristic approaches. The proposed ANP methodology is a useful decision aid for VCs that helps to valuate selected ventures.

The commonly used valuation techniques in corporate finance (e.g. discounted cash flow method, earning multiple method and net asset method, etc.) depend on strict assumptions and require information that new ventures typically cannot provide (such as accounting information). Hence, their applicability is severely limited in valuating early-stage new ventures and both venture capitalists and entrepreneurs are frustrated by huge variance of valuations computed from the extant methods for the same new venture

ISSN 1936-6744
https://doi.org/10.13033/ijahp.v10i1.511

(Miloud, Aspelund, & Cabrol, 2012). Uncertainty and risk related to product creation and commercialization, human resource management issues, lack of technological knowledge etc. are inherent features for startups

Thus, VCs must make their decision under uncertainty and risk without a sufficient amount of financial records. All these facts are major requisites for using heuristic rules in evaluation, and as a result in valuation of startups. On the other hand, although the expert VC's intuition is valuable, it is often biased resulting in suboptimal decisions (Zacharakis & Meyer, 2000).

The proposed ANP methodology makes it possible to assess all criteria that are valuable for VCs without sufficient simplification of the problem. ANP startups ratings may be used as weights for determining startups valuation. For example, a target startup may be included in an ANP model with an already funded similar start up in order to determine an appropriate valuation of the target. The valuation of the considered startup will be determined through final weights of the alternatives. Thus, the ANP approach may considerably extend the scope of comparative valuation methods.

Furthermore, the problem of evaluating startups arises not only in the case of their valuation, but also occurs in the selection of winners at startup competitions. At some competitions, the startups may be very different from each other, so the right evaluation of the competitors may be a very complicated task. Since winners experience a positive effect of visibility and reputation, a fair and impartial selection of a winner is the best guarantee for adequate funding.

The proposed ANP model uses one expert who is responsible for model building and making comparisons. However, the ANP may be also applied in the case where a group of experts dealing with framing a constructed network structure. Aczel and Saaty (1983) proved that the unique way to combine reciprocal individual judgments into a corresponding reciprocal group judgment is by using their geometric mean.

4.2 Limitations

As with any methodology, ANP/AHP has its possible limitations. The first one concerns the number of included criteria and alternatives. ANP/AHP does not work optimally in the case where the number of alternatives is large; therefore, it cannot be applied at the screening stage of investment. Therefore, at first, VCs must screen the hundreds of proposals by using, for example, actuarial decision aides or simple heuristic rules (Zacharakis & Meyer, 2000; Woike, Hoffrage, & Petty, 2015). Those ventures that survive the initial stage can then be subjected to deep analysis with ANP.

Another approach that works with a large number of items, for example, is to use an extension of AHP structuring by incorporating it into another method of prioritization known as Best-Worst scaling (Lipovetsky, 2016).

Zacharakis and Meyer (2000) also conclude that as more information is available to the decision, the VC's predictive accuracy substantially decreases. Although this statement relates to heuristic decision making, it partly concerns ANP too. In spite of the fact that ANP helps to analyze complex VC decision problems through including as many network structures, decision criteria and interactions between them as needed, when the number of criteria is large, the amount of time needed to complete the pairwise comparison will be considerably long. Furthermore, pairwise comparison value might be inconsistent due to this massive number of comparisons. As a result, quality of perception of the comparisons will be reduced. To solve this problem, different ways to improve the consistency of judgements have been discussed (Saaty, 2003; Koczkodaj and Szybowski, 2016). Another solution is to use incomplete pairwise comparisons (Fedrizzia and Giove 2007; Bozóki, Fülöp, & Rónyai, 2010). Therefore, it is the expert's responsibility to determine the degree of the model's complexity that would make ANP more applicable.

In spite of the requirement that an allowable consistency ratio must be not more than about .10, the requirement of 10% cannot be made smaller, such as 1% or 0.1%, without trivializing the impact of inconsistency. Saaty (2013) noticed that inconsistency itself is important because without it new knowledge that changes, preference cannot be admitted. Assuming that all knowledge should be consistent contradicts experience, which requires continued revision of understanding.

The second limitation of building effective ANP models involves the fact that feedback on the quality of VC's decision is slow in coming (Zacharakis & Meyer, 2000). It generally takes 7 years to identify the portfolio winners, and 2 to 3 years to identify the losers (Timmons & Spinelli, 2004). Thus, slow feedback makes it difficult to adjust ANP approach for VCs in their decision processes.

5. Conclusion

The research was aimed at applying ANP to evaluate and select startup businesses for funding. We proposed the idea that to be transparent and understandable, VCs should not collapse the complexity of the decision process into a simplistic scheme. VCs should decompose judgments through elaborate structures and organize their reasoning and calculations in sophisticated ways. Experience indicates that it is not very difficult to do this although it takes more time and effort. Indeed, we must use feedback networks to arrive at the kind of decisions needed to cope with the future (Saaty & Vargas, 2006).

Thus, ANP deliberately synthesizes heuristic and analytic approaches and considerably extends the idea of making business decisions under uncertainty. ANP allows considering the complexity of the problem and uses expert's pairwise comparisons based on heuristics. In ANP, heuristics is used without reducing the complexity of the task and thus helps to avoid the systematic error. On the other hand, ANP is not a heuristic method; it is a mathematical theory that makes it possible to deal with all kinds of dependence and feedback between decision criteria and alternatives and examines the problem from different angles (in our study these are Benefits-Opportunities and Risks).

Despite the potential benefits of applying the ANP methodology in VCs decision-making process, Shepherd and Zacharakis (2002) mentioned that, "VCs rarely use decision aids and thus may be missing an opportunity. We hope that the proposed example of applying the ANP in VCs decision making and the developed Multichoice decisions software encourages researchers to further explore ANP in the area of VC investment decisions. We expect that applying heuristics as part of the analytical process will lead to other results than using heuristics per se. However, this statement must be proved in future research.

REFERENCES

Aczel, J., Saaty, T. (1983). Procedures for synthesizing ratio judgments. *Journal of Mathematical Psychology, 27(1),* 93-102. Doi: https://doi.org/10.1016/0022-2496(83)90028-7

Afful-Dadziea E, Oplatkováa, Z.K., Nabareseh, S. (2015). Selecting start-up businesses in a public venture capital financing using Fuzzy PROMETHEE. *19th International Conference on Knowledge Based and Intelligent Information and Engineering Systems*. *Procedia Computer Science, 60*, 63-72. Doi: https://doi.org/10.1016/j.procs.2015.08.105

Beim, G., Lévesque, M. (2004). Selecting projects for venture capital funding : A Multiple Criteria Decision approach. *Technical Memorandum Number 791,* Weatherhead School of Management, Case Western University.

Bertoni, F., Colombo, M.G., Grilli, L. (2011). Venture capital financing and the growth of high-tech start-ups: Disentangling treatment from selection effects. *Research Policy, 40(7),* 1028-1043. Doi: https://doi.org/10.1016/j.respol.2011.03.008

Beshah, B., Kitaw, D. (2013). AHP application in a financial institution. *International Journal of the Analytic Hierarchy Process, 5(1),* 54-71. Doi: http://dx.doi.org/10.13033/ijahp.v5i1.135

Bhandari, A., Nakarmi, A. (2016). A financial perfomance evaluation of commercial banks in Nepal using AHP model. *International Journal of the Analytic Hierarchy Process, 8(2),* 318-333. Doi: http://dx.doi.org/10.13033/ijahp.v8i2.368

Bozóki, Sándor, János, Fülöp, Rónyai, L. (2010). On optimal completion of incomplete pairwise comparison matrices. *Mathematical and Computer Modelling, 52 (1-2*), 318-333. Doi: https://doi.org/10.1016/j.mcm.2010.02.047

Camerer C. F., Loewenstein, G., Prelec, D. (2004). Neuroeconomics: Why economics needs brains. *Scandinavian Journal of Economics, 106 (3),* 555-579. Doi: 10.1111/j.0347-0520.2004.00377.x

Chemmanur, T., Krishnan, K., Debarshi K. Nandy. (2008). How does venture capital financing improve efficiency in private firms? A look beneath the surface. *Review of Financial Studies, 24(12),* 4037-4090. Doi: https://doi.org/10.1093/rfs/hhr096

Dimov, D., Shepherd, D.A., Sutcliffe, K.M. (2007). Requisite expertise, firm reputation, and status in venture capital investment allocation decisions. *Journal of Business Venturing, 22(4),* 481-502. Doi: https://doi.org/10.1016/j.jbusvent.2006.05.001

Fielden, S. L., Davidson, M.J., Makin, P.J. (2000). Barriers encountered during micro and small business start-up in North-West England. *Journal of Small Business and Enterprise Development, 7(4)*, 295-304. Doi: https://doi.org/10.1108/EUM0000000006852

Fedrizzia, M., Giove,S. (2007). Incomplete pairwise comparison and consistency optimization. *European Journal of Operational Research, 183(1),* 303-313. Doi: https://doi.org/10.1016/j.ejor.2006.09.065

Forbes, R. (2017). *School of a young billionaire*. http://www.forbes.ru/school

Gompers, P. A., Lerner, J. (2004). *The venture capital cycle (Second edition).* Cambridge, MA: MIT Press.

Gui-lan, Hu. (2011). An improved AHP-based evaluation study on the investment risk of venture capital company. *Fourth International Symposium on Knowledge Acquisition and Modeling, 2011,* 17-20. Doi:10.1109/KAM.2011.12

Hall, J. Hofer, C.W. (1993). Venture capitalists' decision criteria in new venture evaluation. *Journal of Business Venturing, 8(1),* 25–42. Doi: https://doi.org/10.1016/0883-9026(93)90009-T

Helm, R., Manthey, L., Scholl, A. Steiner,M. (2002). Preference measurement with conjoint analysis and AHP: An empirical comparison. In Ulrike Leopold-Wildburger et. al. (Eds), *Operations Research Proceedings*, 517-524. Heidelberg: Springer Berlin. Doi: https://doi.org/10.1007/978-3-642-55537-4_84

Helm, R., Steiner, M. Scholl, A. Manthey, L. (2004). A comparative empirical study on common methods for measuring preferences. *Jenaer Schriften zur Wirtschaftswissenschaft : Arbeits- und Diskussionspapiere der Wirtschaftswissenschaftlichen Fakultät der Friedrich-Schiller-Universität Jena.* Doi: 10.1504/IJMDM.2008.017408. Doi: 10.1504/IJMDM.2008.017408

Hsu, D. K, Haynie, J.M., Simmons, S.A., McKelvie, A. (2014). What matters, matters differently: a conjoint analysis of the decision policies of angel and venture capital investors. *Venture Capital*, *16(1),* 1-25. https://doi.org/10.1080/13691066.2013.825527

Hudson, J. Khazragui, H.F. (2013). Into the valley of death: Research to innovation. *Drug Discovery Today, 18(13-14),* 610-613. Doi: https://doi.org/10.1016/j.drudis.2013.01.012

Ijzerman, M. J., Van Til, J.A., Bridges, J.F.. (2010). A comparison of Analytic Hierarchy Process and conjoint analysis Mmethods in assessing treatment alternatives for stroke rehabilitation. The *Patient - Patient-Centered Outcomes Research, 5(1), 45-56.* Doi: https://doi.org/10.2165/11587140-000000000-00000

Koczkodaj, W.W., Szybowski. J. (2016). The limit of inconsistency reduction in pairwise comparisons. *International Journal of Applied Mathematics and Computer Science, 26 (3),* 721–729. Doi: https://doi.org/10.1515/amcs-2016-0050

Landström, H. (2007). *Handbook of Research on Venture Capital*. Edward Elgar Publishing.

Lipovetsky, S. (2016). AHP structuring in best-worst scaling and the secretary problem. *International Journal of the Analytic Hierarchy Process,* *8(3)*, 502-513. Doi: http://dx.doi.org/10.13033/ijahp.v8i3.332

Lu, Z., Shen, Y. (2011). The study on venture capital project appraisal using AHP-Fuzzy comprehensive evaluation methods. *International Journal of Advancements in Computing Technology, 3(8),* 50-56.

MacMillan, I.C., Zeman, L., SubbaNarasimha. P.N. (1987). Criteria distinguishing unsuccessful ventures in the venture screening process. *Journal of Business Venturing, 2(2)*, 123-137. Doi: https://doi.org/10.1016/0883-9026(87)90003-6

Meißner, M., Decker, R. (2009). An empirical comparison of CBC and AHP for measuring consumer preferences. In T. Tjader (Ed). *Proceedings of Tenth International Symposium on Analytic Hierarchy Process (ISAHP 2009),*University of Pittsburgh, USA: Creative Decisions Foundation.

Milkova, M., Andreichikova, O. (2016). Software announcement: Multichoice as new software for decision making with Analytic Network Process. *International Journal of the Analytic Hierarchy Process, 8(2),* 388-400. Doi: http://dx.doi.org/10.13033/ijahp.v8i2.413

Miloud, T., Aspelund, A., Cabrol, M. (2012). Startup valuation by venture capitalists: an empirical study. *Venture Capital: An International Journal of Entrepreneurial Finance, 14 (2-3),* 151-174. Doi: https://doi.org/10.1080/13691066.2012.667907

Mitteness, C., Sudek, R., Cardon, M.S. (2012). Angel investor characteristics that determine whether perceived passion leads to higher evaluations of funding potential. *Journal of Business Venturing, 27(5),* 592-606. Doi: https://doi.org/10.1016/j.jbusvent.2011.11.003

Monika, D., Sharma, A.K. (2015). Venture capitalists' investment decision criteria for new ventures: A review." *XVIII Annual International Conference of the Society of Operations Management (SOM-14). Procedia - Social and Behavioral Sciences, 189*, 465-470. Doi: https://doi.org/10.1016/j.sbspro.2015.03.195

Mousavi, S., Gigerenzer, G. (2014). Risk, uncertainty, and heuristics. *Journal of Business Research, 67,* 1671-1678. Doi: https://doi.org/10.1016/j.jbusres.2014.02.013

Narayanasamy, C., Hashemoghli, A., Rashid, R.M.. (2012). Venture capital pre-investment decision making process: An exploratory study in Malaysia. *Global Journal of Business Research, 6(5),* 49-63.

Pakizeh, K., Hosseini, M. (2015). Venture capital investment selection based on PROMETHEE. *Applied Mathematics in Engineering, Management and Technology, 3(1),* 566-572.

Robinson, R.B. (1987). Emerging strategies in the venture capital industry. *Journal of Business Venturing, 2(1),* 53–77. Doi: https://doi.org/10.1016/0883-9026(87)90019-X

Saaty, T. L. (1996). *Decision making with dependence and feedback: The*

Analytic Network Process. Pittsburgh: RWS Publications.

Saaty, T.L. (2003). Decision-making with the AHP: Why is the principal eigenvector necessary. *European Journal of Operational Research*, *145*, 85-91. Doi: https://doi.org/10.1016/S0377-2217(02)00227-8

Saaty, T. L. (2008a). The Analytic Hierarchy and Analytic Network measurement processes: Applications to decisions under risk. *European Journal of Pure and Applied Mathematics, 1(1),* 122-196.

Saaty, T. L. 2(008b). Relative measurement and its generalization in decision making – why pairwise comparisons are central in mathematics for the measurement of intangible factors: The Analytic Hierarchy/Network Process. *RACSAM - Revista de la Real Academia de Ciencias Exactas, Fisicas y Naturales. Serie A. Matematicas, 102(2),* 251–318. Doi: https://doi.org/10.1007/BF03191825

Saaty, T.L. (2010). *Principia mathematica decernendi: Mathematical principles of decision making: Generalization of the Analytic Network Process to neural firing and synthesis*. Pittsburgh, PA: RWS Publications.

Saaty, T.L. (2013). On the measurement of intangibles. A principal eigenvector approach to relative measurement derived from paired comparisons. *Notices of the AMS, 60(2),* 192-208.

Saaty, T.L., Vargas. L.G. (2006). *Decision making with the Analytic Network Process: economic, political, social and technological applications with benefits, opportunities, costs and risks*. New York: Springer.

Saracoglu, B.O. (2015). An AHP application in the investment selection of small hydropower plants in Turkey. *International Journal of the Analytic Hierarchy Process, 7(2)*, 211-239. Doi: http://dx.doi.org/10.13033/ijahp.v7i2.198

Savaneviciene, A., Venckuviene, V., Girdauskienea, L. (2015). Venture capital a catalyst for start-ups to overcome the "Valley of Death": Lithuanian case. *4th World Conference on Business, Economics and Management, WCBEM*. *Procedia Economics and Finance, 26*, 1052-1059. Doi: https://doi.org/10.1016/S2212-5671(15)00929-6

Schol, A., Manthey, L., Helm, R., Steiner, M. (2005). Solving multiattribute design problems with Analytic Hierarchy Process and conjoint analysis: An empirical comparison. *European Journal of Operational Research*, 164, 760-777. Doi: https://doi.org/10.1016/j.ejor.2004.01.026

Shepherd, D.A., Zacharakis. A. (1999). Conjoint analysis: a new methodological approach for researching the decision policies of venture capitalists. *Venture Capital*, *1(3),* 197-217. Doi: https://doi.org/10.1080/136910699295866

Shepherd, D.A., Zacharakis, A. (2002). Venture capitalists' expertise: A call for research into decision aids and cognitive feedback. *Journal of Business Venturing, 17(1),* 1-20. Doi: https://doi.org/10.1016/S0883-9026(00)00051-3

Shijian, F. Yinyan, C. (2015). AHP-Fuzzy comprehensive evaluation model of venture investment and financing system: Based on the case of incubation base in Anhui. *Canadian Social Science, 11(1),* 148-153.

Simon, H. A. (1957). *Models of Man*. New York: Wiley & Sons.

Su, H., Jiang, R. Ma, X. (2009_. Risk evaluation of venture capital based on AHP and grey relational analysis methods. *International Conference on Information Management, Innovation Management and Industrial Engineering, 2009*, 316-320. Doi: 10.1109/ICIII.2009.536

Timmons, J.A. Spinelli, S. (2004). *New venture creation: Entrepreneurship for the 21st century*. Boston: McGraw-Hill/Irwin.

Tripathi, A., Vidyarthi, D.P. (2015). Task allocation on cloud resources using Analytic Network Process. *Proceedings of International Conference on Advances in Computer Engineering and Applications (ICACEA)*, 971-978. Doi**:** 10.1109/ICACEA.2015.7164847

Tversky, A. Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science, New Series, 185(4157),* 1124-1131. Doi: 10.1126/science.185.4157.1124

Wiratno, S., Latiffianti, E., Wirawan, K.K. (2015). Selection of business funding proposals using analytic network process: a case study at a venture capital company." *Industrial Engineering and Service Science. Procedia Manufacturing* 4: 237-243. Doi: https://doi.org/10.1016/j.promfg.2015.11.037

Woike, J.K., Hoffrage, U., Petty, J.S.. (2015). Picking profitable investments: The success of equal weighting in simulated venture capitalist decision making. *Journal of Business Research, 68(8),* 1705–1716. Doi: https://doi.org/10.1016/j.jbusres.2015.03.030

Zacharakis, A.L., Meyer, G.D. (1998). A lack of insight: Do venture capitalists really understand their own decision process?" *Journal of Business Venturing, 13(1),* 57-76. Doi: https://doi.org/10.1016/S0883-9026(97)00004-9

Zacharakis, A.L., Meyer, G.D. (2000). The potential of actuarial decision models: Can they improve the venture capital investment decision?" *Journal of Business Venturing, 15(4),* 323-346. Doi: https://doi.org/10.1016/S0883-9026(98)00016-0

Zacharakis, A., Shepherd, D.A. (2001). The nature of information and overconfidence on venture capitalists' decision making. *Journal of Business Venturing, 16(4),* 311-332. Doi: https://doi.org/10.1016/S0883-9026(99)00052-X

Zacharakis, A., Shepherd, D.A. (2004). A non-additive decision-aid for venture capitalists investment decisions. *European Journal of Operational Research,* 162, 673–689. Doi: https://doi.org/10.1016/j.ejor.2003.10.028