SZÉCHENYI EGYETEM
UNIVERSITY OF GYŐR

Doctoral School of Regional and Business Administration Sciences

Gergely Géczi

Non-equilibrium in ice hockey: understanding the game with a transdisciplinary approach

Doctoral dissertation

Supervisor: László Imre Komlósi, professor

Győr,
November 2022

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Author's Declaration

No portion of the work referred to in this dissertation has been submitted in support of an application for another degree or qualification of this or other university or other institution of learning.

Furthermore, this dissertation contains no material previously written and/or published by another person, except where an appropriate acknowledgment is made in the form of bibliographical references.

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ABSTRACT

Abstract of the dissertation submitted by **Gergely Géczi** for the degree of Doctor of Philosophy under the title: **Non-equilibrium in ice hockey: understanding the game with a transdisciplinary approach.**

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Complex systems theory serves as a foundation to study real-world systems since the processes identified by the theory are well observable in systems such as an ice hockey team, or a game between ice hockey teams. These systems are inherently characterized by openness and the presence of non-equilibrium behavior. In many disciplines, non-equilibrium models were adopted and used for analyzing contextualized phenomena, while team sports science, especially in Hungary, did not yet exploit the usage of this up-to-date knowledge. As seen in many disciplines, an equilibrium-dominated paradigm is changing towards non-equilibrium domination. In this dissertation the equilibrium paradigm is characterized by elements of the system converging towards an existing or assumed equilibrium point, while in the non-equilibrium paradigm, divergence is present as elements are moving away from the equilibrium point. The dissertation focuses on ice hockey as a method of understanding complex systems and draws conclusions based on the emergent phenomena from the analysis of participants. Winning and losing are processes that are found in many real-world situations, not only professional sport, and these two are assumed to be attractors of competitive situations. As a consequence of the research process, non-equilibrium behavior of systems was identified to offer stable attractors that might supersede winning and losing attractors. These new attractors are named “Winning through innovation” and “Losing through innovation”. Although innovation is present in the case of equilibrium paradigm systems as well, its use is secondary, as winning is the number one goal for these systems. In the non-equilibrium paradigm, innovation is the number one aim, and winning is a consequence of the innovation process. This novelty offers a system that the competitive edge is continually renewed and pushes systems to their maximal innovation potential, which would otherwise be limited by the equilibrium paradigm. The evolution of a non-equilibrium paradigm following system results in a diverse, highly complex and well-fitting system that promotes development of the self, next to the

development of teamwork skills, which makes the system attractive for those seeking personal development as well.

1. INTRODUCTION

The evolution of the current research activity resulting in this dissertation originates from the intrinsic motivation of the author, relying on his personal experience as a former professional ice hockey player and currently an ice hockey coach. As a former player and a coach, he was often confronted with real problems. These problems have been examined and scrutinized through the research process with a transdisciplinary approach. The first stage of the study examines whether playing ice hockey contributes to the emotional intelligence and resilience, two important psychological skillsets of its players. This is discussed in the second chapter. The main idea behind it is whether such a contributing effect could be proven, so that ice hockey could be used as a method of increasing psychological capital of any organization on the market. In the second stage of the research, described in the third chapter, the research activity then turns into a direction in which a proposed model of ice hockey team performance was created, as a consequence of which interview questions were formulated. They enabled the author to conduct interviews through which the proposed model was to be finalized. The interviews were conducted with highly qualified experts of Hungarian ice hockey. The third stage of the research process is described in chapter four which was to provide definitions for the factors of the proposed model by synthesizing existing definitions from the scientific literature so that they would fit the sport context. The fourth stage described in the fifth chapter was to write the article in which the author with co-authors give account of the interviews with the experts, and finalize the proposed model of ice hockey team performance. The responses of the interviewed experts were homogenous, enabling the authors to make clearly needed adjustments in the model. The fifth stage of the research process presented in the sixth chapter consists in a statistical examination of Hungarian senior first league games in which events were selected out which might be considered as antifragile behavior of teams. Although antifragile behavior in such events occurred relatively rare, the authors were able to analyze them and got significant results with the use of statistical methods. The practical implication of the study is to determine when antifragile response can be instigated by a coach. In other words, when the opposite team scores a goal resulting a leading position with one or two goals, the coach can strengthen the line of players on the ice which offers a convex and the emergence of antifragile behavior.

In order to show the storyline, the first part of the research journey consisted in examining the psychological aspects of playing ice hockey. Then attention was turned to creating a theoretical model for high team performance, offering novelty to the scientific knowledge base of the field. The final result in the process was the examination of when and under what conditions antifragile behaviors and situations occur in Hungarian ice hockey games. Thus, the author was able to investigate the characteristics of antifragility in sport settings.

The fundamental motivation for the research was to capture and understand natural processes in the relations of a human being and their environment, in which sports figure as an emphatic domain. In the observation of the author, natural processes can be best characterized as states of permanent non-equilibrium, which can be learned to cope with. Thus, the title of the dissertation addresses the main characteristic of ice hockey considered as a complex, open, ever-changing system. The centrality of non-equilibrium builds on the fact that ice hockey teams, and their games are better understood when treated as an open system, compared to a closed system concept. The concept of the dissertation has been constructed by assuming the following ideas.

Firstly, ice hockey teams are seen as complex, open systems having reciprocal relationships with their environments. These characteristics imply the use of phenomena such as non-linearity, emergence and synergistic effects when the components of the system interact with each other. As in a game between two teams, two complex systems are playing against each other, their interactions are inevitably complex as well. Although the game rules are the same for the two teams, there is plenty of room for uniqueness and novelty presented by the teams in emergent phenomena. Secondly, the teams are categorized by two characteristics: one of them is a follower of the equilibrium concept, the other is a follower of the non-equilibrium concept. In the former case, there exists a single optimal behavior of the team, and the system desires to reach the optimal state. Therefore, the team following the equilibrium concept is characterized by movements towards a single optimum behavior. The team following the non-equilibrium has different challenges: its main idea is to expand the landscape (the possible “gain” of the game) through diverging from the starting point. In this case, equilibrium also exists, but the system finds its stability through constant divergence from this equilibrium point by exploring

the landscape beyond its boundaries. Therefore, a non-equilibrium concept following team is characterized by constant innovation through the exploration of the landscape, beyond its boundaries, resulting in additional gains. The landscape is a mental construct which helps to envisage the possible gains of a given element of the system. The landscape has a winners' sector and a losers' sector related to the role of innovation during the game.

The dissertation is committed to examining how the two concepts are contributing to the wellbeing of the participants of ice hockey. The dissertation makes an attempt to understand interpersonal dynamics through ice hockey. In the author's view, personal development and team development are real world problems to be addressed by scientific methods for which end a higher level of understanding is required for professional ice hockey to identify the direction towards which it should evolve. The term landscape is understood as an environment for personal- and team development. Although the findings are specific for ice hockey settings, general conclusions can be drawn from the examination of participant behaviors. Therefore, ice hockey is used as an example to understand the behaviors observed in complex, open systems.

Emotional intelligence (EI) and resilience are both psychological skills that contribute to the psychological capital of the team they belong to. The analysis of whether playing ice-hockey may improve these skills seemed unavoidable, as it represents the individual level of analysis which is the basis from where the research process evolved. The team level analysis of EI lacks existing measurement scales and theory to support its measurement, therefore, it was placed outside of the research scope of the current research. The team level analysis of resilience could be conducted on the basis of performance measures, although this area lacks measurement assets as well. On the team level, antifragility appeared to be more beneficiary to focus on, as according to the evolution model used in the research process, a team behaving in an antifagile way inevitably evolved through being resilient.

As observed in real-world situations, a good proportion of the natural systems behave as open systems in which equilibrium, as a default case, is a desired state. It is to be acknowledged, however, that such kind of equilibrium is never reached completely. It is also to be observed that there are closed systems in which a different kind of equilibrium is desired by the system. It is understandable why studying closed system mechanics is helping to explore the laws of

the universe, as human beings are likely to be finite creatures, and their bounded rationality is taken for granted. In a closed system, the total amount of energy and information is finite, and entropy tends towards its maximal value. In this case, an equilibrium state is the final aim of the system. It is understood as mixing hot and cold water in an isolated container, resulting in having an equalization of the temperatures. It is important to understand that the equilibrium phase is not the only possible end state of such a system, but it is the highest probability end state. In open systems, the container is not isolated, and the boundaries of the system are permeable, resulting in constant energy and information inflow and outflow in the system. This continuous supply of energy and information can also end in a stable, non-equilibrium state. In our conception, the stability of a non-equilibrium state is also a desired state of conscious agents. Also, the openness of the boundaries enables the outer supply to change, therefore, the system is dynamic, and it models real-life phenomena in a more accurate way compared to closed systems. Although the rationality of human beings is bounded, it is worthwhile studying open systems as they exist under natural circumstances in greater amounts than closed systems. Bounded rationality in this dissertation is understood as a concept that human beings are incapable of being fully informed about the decisions they make, and therefore, the aim of every decision is to satisfy a certain need at a given moment of time, without searching for further decision alternatives. The mental limits of human beings present a limitation for the study of open systems, although it is worthy to study them through the lenses of complexity, as the methods of the scientific field are all aimed to better understand systems that exceed the limits of human capabilities with traditional methods. As evidence suggests, even the managers of the highest level of sports are facing the consequences of bounded rationality, caught in their decision-making when buying players in their respective teams (Berri, Brook and Schmidt, 2007). Bounded rationality is a constraint that players and teams face when performing. It is very likely that different teams are constrained at different levels: players have differing capabilities to gather and process information that affects their decisions. Although it is an important concept, it is outside of my research scope because of the fact that most of the information the player faces are processed subconsciously, making them hard to verbalize and measure. The nature of this constraint appears to be a strong limiting factor for decision making on the ice, having effect on the creativity of the players. Bounded rationality is also an opportunity: as the players have a limited number of mental processes, the coach has the opportunity to load the players mentally into a high-performance state. If the rationality of the

players were unlimited, no outstanding performance could be achieved, only small performance variability could happen on the games, which would not be welcomed by athletes and other participants.

The concept of non-equilibrium in this dissertation covers a process in which the disequilibrium is constantly renewed, and as a result, a continuous non-equilibrium state emerges. The flow of knowledge and information is present in this system, on the basis of difference between the components. This diversity creates potential for the system to fit well in the ever-changing environment. The increase of complexity of ice hockey teams is a desired series of actions, as complexity inherently involves non-linear processes, which might serve as a base for outstanding performance. Non-equilibrium also creates the conditions for antifragility to emerge, as it is based on the criteria of convexity in this dissertation, which is inherently an out-of-equilibrium state. A team that is in a constant non-equilibrium state is, therefore, capable of performing better than equilibrium teams, by both the capacity for outstanding performance caused by increased complexity and through evolution towards antifragile behavior.

Chaos as a term, although rarely used, shows up in the dissertation as well. A chaotic state of a system is characterized by non-linear divergence on the landscape, which enables the exploration of new attractors. Attractors are defined in this dissertation as the end states of game processes: winning or losing. The exploratory process might result in discovering new attractors that have attracting effects on the participants of the game. Complexity is defined as a system having many elements (ice hockey teams consist of between 25 to 30 participants per team) interacting in a way that unexpected behaviors emerge involving synergetic characteristics. The transdisciplinary approach towards the research enables the author to collect the relevant contributions from many relevant disciplines which do contribute to the deep understanding of the phenomena experienced in ice hockey settings. The publications included in the subsequent chapters of this dissertation are all pieces of the big picture which becomes understandable when the parts get put together.

It is a favorable trend that the scientific knowledge about ice hockey and the related, complex systems theory is growing, however, the creation of a complex theoretical model and the capturing of antifragility as a behavior of ice hockey teams became necessary for the research

which at the same time, identified the research gap in the literature. The complexity of the current dissertation lies in the fact that it considers both the players and the coach of a team together with their interactions. Therefore, the current research is partially to fill a gap and partially to provide a novelty. It is an additional contribution of the dissertation to highlight the state of affairs according to which there is a significant difference between Hungarian literature focusing on sports and their international counterparts. It has been observed that in the Hungarian literature there are no traces of the adoption of theoretical concepts, such as complex systems, chaos, the concept of non-equilibrium and antifragility.

Within the conceptual approach of transdisciplinarity, the author processed numerous scientific papers from the following fields: complex systems theory, networks theory, ecology, non-equilibrium dynamics, chaos theory and studies related to sport science, including sport psychology. The knowledge base has been built on a search for analogies and convertible patterns, together with their possible applications in sport settings.

In many disciplines, new, paradigm-changing concepts have emerged in the light of new scientific discoveries, mostly governed by natural sciences. The discipline of economics is highly influenced by the concept of misbehaving. The discipline of sport science is still highly operating in an equilibrium-based paradigm, meanwhile many other disciplines have adopted the non-equilibrium concept. A knowledge gap appears here as non-equilibrium concepts are not yet adopted and their use is not yet examined in sport science. The scientific world offers modern knowledge that helps to incorporate the new concepts whose application is a must to practitioners and academics who want to develop their problem fields.

Misbehaving is known as a paradigm-changing theory rooted in the psychology of economics and its basic concept supports the idea that ice hockey teams are functioning as complex systems through the bottom-up direction of processes. Misbehaving itself is understood in the conceptual framework of the author as a process in which an agent of a system creates his or her own rules, opposing the rules that originate from a top-down source. The concept of misbehaving could be related to the divergent behavior in a non-equilibrium system.

1.1 GLOSSARY

Term	Definition
Attractor	An immaterial creature on the landscape that attracts the elements of a system.
Chaos	A state of a system in which unpredictable behavior is present, and the order is minimal.
Complex, complexity	A state of a system in which many elements are interacting in a way that enables emergent phenomena to arise.
Convergence	A process in a system in which an element behaves as continually getting closer from the existing, or assumed equilibrium point.
Divergence	A process in a system in which an element behaves as continually getting far from the existing, or assumed equilibrium point.
Emergent phenomena	Phenomena that arise from the interactions of the elements of a complex system. Mostly unpredictable.
Equilibrium concept	A state of a system in which all the elements are having the same characteristics.
Exploratory behavior	A process in a system that enables the elements to broaden the landscape of the system.
Non-equilibrium concept	The exact opposite of equilibrium, all the elements of a system having different characteristics.
Landscape	The landscape in this dissertation is referred as the two-dimensional, mentally constructed map of the system in which the elements are moving.
Transdisciplinary approach	The method of obtaining knowledge from various disciplines in a way that the obtained knowledge is convertible to a given discipline.

Source: own creation

1.2 LIST OF PAPERS

Chapter II: Ice-Hockey as a Potential Improvement for Emotional Intelligence and Resilience: Increasing Psychological Capital.
Conference paper, Published: September 2020

Reference: Géczi, G. and Komlósi, L. I. (2020) 'Ice-Hockey as a Potential Improvement for Emotional Intelligence and Resilience: Increasing Psychological Capital', *Economic and Social Development: Book of Proceedings*, Győr, 4-5 September 2020.

The author of this dissertation contributed 85 per cent of the work for this research paper.

Chapter III: Research Design for Developing and Validating Ice-Hockey Team Diagnostics Scale.
Conference paper, Published: July 2021

Reference: Géczi, G. (2021a) 'Research Design for Developing and Validating Ice Hockey Team Diagnostics Scale', *International Journal of Sport and Health Sciences,* volume 15(8) [online]. Available at: https://publications.waset.org/10012179/pdf (Accessed: 2021. 09. 01)

The author of this dissertation contributed 100 per cent of the work for this research paper.

Chapter IV: Antifragile Approach for Ice-Hockey Team Performance Modeling: The Definitions Component.
Conference paper, Published: September, 2021

Reference: Géczi, G. (2021b) 'Antifragile Approach for Ice-Hockey Team Performance Modeling: The Definitions Component' *12th IEEE International Conference on Cognitive Infocommunications: Proceedings*, Győr, 23-24-25 September 2021.

The author of this dissertation contributed 100 per cent of the work for this research paper.

Chapter V: Complex Ice Hockey Team Performance Model based on Expert Interviews
Journal paper, Published: June, 2022

Reference: Géczi, G., Gurisatti, L. and Komlósi, L. I. (2022) 'Complex Ice Hockey Team Performance Model based on Expert Interviews', *Physical Culture and Sport. Studies and Research,* 95(1), pp. 76-84. https://doi.org/10.2478/pcssr-2022-0013

The author of this dissertation contributed 80 per cent of the work for this research paper.

Chapter VI: Statistical Analysis of Antifragility in Hungarian Ice Hockey Games
Journal paper, Published: June, 2022

Reference: Géczi, G. and Baracskai, Z. (2022) 'Statistical Analysis of Antifragility in Hungarian Ice Hockey Games', *Hungarian Statistical Review,* 5(1), pp. 75-93.

The author of this dissertation contributed 80 per cent of the work for this research paper.

1.3 RESEARCH QUESTIONS

The research questions formulated in this dissertation follows the steps of the learning process the author went through.

First paper
RQ1: Can playing ice-hockey contribute to the Emotional Intelligence level of the players?
RQ2: Can playing ice-hockey contribute to the Resilience level of the players?

The first step of the research focused on whether playing ice hockey has an increasing effect on two important life skill sets, namely emotional intelligence and resilience. These skillsets are considered to be decisive parts of the personality of the players.

Second paper

RQ3: Are the five factors of the coach's operation relevant and sufficient for understanding the complex operation of a coach?

RQ4: Are the five factors of the team's operation relevant and sufficient for understanding the complex operation of the team?

RQ5: How do visible and non-visible interactions arise in the cooperation of coach and players?

RQ6: How does the cooperation of the coach and the team function as a system that supports high performance?

As the second paper was a research design type article in which an explanatory model was created and proposed, research questions 3 to 6 inevitably focus on the different parts of the model. The interview questions aiming to corroborate and finalize the model later were conducted in accordance with these research questions.

Third paper

No research questions were investigated in this paper, instead, the paper serves as a container of definitions of the constituting factor of the proposed model.

Fourth paper

No new research questions were asked in this paper either as they were adopted from the second paper. The interviews and their results are presented in this article relying on which the proposed model of ice hockey team performance was finalized.

Fifth paper

RQ7: What are the characteristics of the three goal events, and do they show antifragile behavior?

This, 7th research question focuses on specific events of an ice hockey game in which antifragile behavior emerges and is observed.

It is to be seen through the research questions that the psychological aspect of ice hockey is strongly addressed, along with the types of knowledge-sets and skill-sets required from the participants of an ice hockey team to perform.

2. CHAPTER: ICE-HOCKEY AS A POTENTIAL IMPROVEMENT OF EMOTIONAL INTELLIGENCE AND RESILIENCE: INCREASING PSYCHOLOGICAL CAPITAL

Reference: Géczi, G. and Komlósi, L. I. (2020) 'Ice-Hockey as a Potential Improvement for Emotional Intelligence and Resilience: Increasing Psychological Capital', *Economic and Social Development: Book of Proceedings*, Győr, 4-5 September 2020.

ABSTRACT

Playing ice-hockey is a fun activity that may bring joy to the life of the players. In this research, the author seeks the answer whether playing ice-hockey has a contributing effect to the emotional intelligence and resilience levels of people. The authors processed the most recent scientific literature in the field and concluded that it is possible that playing this sport has such a causal relationship with the two psychological factors. The research uses quantitative data, collected from 104 participants. To measure emotional intelligence and resilience, validated scales were used. Cronbach's alpha values showed that both scales were reliable measurers of the ability levels. Results suggested that playing ice-hockey only partially contribute to the two measured abilities of people directly, as the improvement in these abilities are stronger connected to the age of the participants than their years of playing ice-hockey. This means if a company wants to increase its psychological capital and gain a competitive edge, it is suggested that they look for other training methods, and employ older employees, as they are likely to possess a stronger psychological power. The research must be continued to identify whether playing other sports may have stronger contributing effect to the psychological capital of companies.

Keywords: Emotional intelligence; Resilience; Ice-hockey; Skills improvement, Psychological capital

2.1 INTRODUCTION

Playing ice-hockey is a fun activity that brings joy to the life of the players, as it offers complex mental and physical challenges to tackle within different in-game and social situations. As one of the authors is a passionate lover of the sport, the authors of this paper became curious if playing ice-hockey can contribute to the psychological abilities of the persons involved. According to Montgomery (1988) and Vescovi et al. (2006), ice-hockey is one of the fastest team sports in the world, physical force, speed, complicated technical elements, cunning tactics and the fight body against body describes it. The speed, the number of stimuli may create situations that require strong psychological power.

In the work of Bhullar (2020), emotional intelligence is defined as the competencies related to understanding, managing and utilizing the emotions of self and other people. In a competitive environment in which many of the existing companies operate, emotionally intelligent employees can contribute much to the overall performance of their companies, mainly by utilizing emotions. In the article of Southwick et al. (2014), different definitions of resilience were identified, but they share some fundamentals: successfully bounce back to harmonic state after an event pushes us out from it. They also claim that it is possible to become even more harmonious after such an event. Resilience is also part of the psychological capital definition of Luthans et al. (2007). When working in an environment that often requires us to mobilize much energy that we use to maintain our mental well-being, resilience becomes a must-have ability. Therefore, if playing ice-hockey is proven to be an efficient contributor for emotional intelligence and resilience, companies can use it as a method to contribute to their employees' ability, and increase its psychological capital. If playing ice-hockey can contribute to the examined two abilities, companies may use it as a method to gain competitive edge over the competitors.

On the society level, such a knowledge is absolutely must-have, as in the 21st century, the importance of having strong psychological power is increasing, especially on the labor market. Luthans et al. (2007) claims that the competitive edge of any company in the 21st century can be earned by people in the company having psychological toughness. The scientific literature uses the term psychological capital when dealing with the psychological toughness of employees of given companies. Building psychological capital is done in two ways: hiring new

employees that have such a psychological toughness and keeping them, and encouraging the existing employees to do activities that are proven to contribute to their psychological power.

2.2 LITERATURE REVIEW

In their meta-analysis, Mattingly and Kraiger (2019) investigated whether emotional intelligence can be trained. They identified 58 published and unpublished longitudinal studies, and calculated Cohen's d to calculate effect size, in order to estimate the effect of the trainings. They found a moderate positive effect, concluding emotional intelligence can be trained and improved. Jonker (2009) examined the effect of an aimed emotional intelligence development program in a longitudinal study with accountant participants. In this research, the Bar-On EQ-i scale was used, in a control group design. The results showed that the group participating in the development program achieved higher scores than the control group, meaning it is possible to improve emotional intelligence with aimed development programs. Foster et al. (2017) claims that emotional intelligence scores of nurses improve over time when applying to a nursing education program. In their longitudinal study, they proved that a significant increasement was measurable in the utilizing emotions part of the scale they used. McEnrue et al. (2009) examined 135 business students in a control-group designed way, in a leadership development program. The participants showed an improvement in trait emotional intelligence, suggesting that well-performed leadership program may have a developing effect on emotional intelligence.

Eika et al. (2019) examined the resilience development of nursing students in a longitudinal study. They suggest that resilience may be highly improved when a trustworthy learning culture is built. Taylor (2019) focused on Resilience trainings to decide whether resilience training is a usable intervention method against burnout. She concluded that without dealing with the environmental factors contributing to burnout, resilience training is an incomplete solution. This means a resilience training, along with focusing with the environmental factors are capable of developing the resilience of people, and protect them against burnout. Denkova et al. (2020) examined whether giving short-form mindfulness training to firefighters can contribute to these people's resilience. After receiving the training, the participants showed a significantly higher resilience level than the control group. According to Azavedo and Shane (2019), the MBA students of a Californian university reached higher levels of resilience when tested after

finishing the problem, than on the test before. This suggests the examined MBA program was capable of improving the resilience of the participating students.

Trottier et al. (2017) claims that when playing sports, coaches may have a positive, developing effect on the life-skills of the players. The coach plays an important role in this development. Friesen (2013) made an analysis on how 16 ice-hockey players from the English professional league regulated the emotions of their teammates when in tough situations which is part of emotional intelligence. As different strategies were identified, the teammates of these examined players could see and learn different strategies to regulate other's emotions. This suggests that playing ice-hockey offers a chance to improve the ability to successfully regulate others emotions, which may become an important ability when working together with colleagues in their companies. Battochio and Stambulova (2019) revealed the coping strategies of 23 Canadian National Hockey League players. As their different carrier situations required different coping strategies, the players learned different strategies when pursuing their carrier goals. Based on this finding, playing ice-hockey may create situations that requires the person to make use of his/her emotions the best to reach the wanted solution to the situation and be resilient. Côté et al. (2014) claims that personal development through sport is possible - they used the Personal Assets Framework to identify the factors determining personal development. The first factor is personal engagement in activities, the second is quality relationships, and the third is appropriate settings. If a player of ice-hockey gives the chance to this sport to contribute to his/her personal development and these three factors are focused on, playing ice-hockey may have a developing effect on the personality of the player. This paper also suggests that playing ice-hockey does have a developing effect on the person, however, the paper does not mention psychological power as subject of development. Géczi et al. (2009) used CSAI-2, ACSI-28 and STPI-Y self-evaluation questionnaires on the U16, U18 and U20 national ice-hockey team of Hungary. They found significant difference between the age groups in terms of psychological power, meaning psychological power may change when becoming older. Kaplánová (2019) used self-report scales to measure the self-esteem, anxiety and coping strategies to handle stress on 40 male ice-hockey players. They found that coping strategies against stress varies according to the level of self-esteem and anxiety. Reduced anxiety level and increased self-esteem may increase the success in coping with stress. This paper suggests that ice-hockey players face stressful situations, in which coping strategies can be learnt. When in stressful situations, being

resilient is an important ability as it may contribute to the efficient management of stress, according to Lester et al. (2020). In addition, Malinauskas et al. (2019) studied the relationship between emotional intelligence and stress coping strategies. They used the Schutte Self-Assessment Questionnaire to measure emotional intelligence, and the questionnaire by Grakauskas and Valickas (2006) questionnaire to identify stress coping strategies. On a sample of 123 participants, they found a significant relationship between the stress coping strategy and the ability to evaluate and express own emotions, which is part of emotional intelligence. This means, when ice-hockey players face stressful situations and learn the possible coping strategy against it, their emotional intelligence may improve as well. Géczi et al. (2008) explored the differences between U18 and adult ice-hockey players with the use of CSAI-2, ACSI-28 and STPI-Y psychometric measures. They found that adult players can handle stressful situations easier than U18 players, which may be caused by having more experience. Kurudirek et al. (2016) found that teaching ice-hockey through educational games has a positive impact on the cognitive development of children aged 8-12. According to McBride (2010), cognitive development is positively correlated with the development of emotional intelligence. Therefore, this paper suggests playing ice-hockey might have a developing effect on the emotional intelligence of the players through their cognitive development.

Based on the processed literature, emotional intelligence and resilience abilities of people can be improved through different activities. Older and more experienced ice-hockey players are having stronger coping ability and psychologically measurable differences compared to young ice-hockey players, suggesting that playing ice-hockey may be an activity that improves these abilities.

2.3 METHOD

Firstly, the author had two research questions, and a targeted literature review was done to identify whether this field is covered by scientific knowledge, and whether the research questions need modification. Though the literature review revealed that there is knowledge connectible with the research questions, the coverage was not satisfactory. A knowledge gap was found here. The research questions and hypotheses are the following:

Research question one: Can playing ice-hockey contribute to the emotional intelligence level of the players?

Hypothesis one: I assume that playing ice-hockey does contribute to the emotional intelligence level of the players.

Research question two: Can playing ice-hockey contribute to the resilience level of the players?
Hypothesis two: I assume that playing ice-hockey does contribute to the resilience level of the players.

The cross-section study uses two selected psychological abilities - emotional intelligence and resilience to identify whether playing ice-hockey can contribute to the player's psychological power. An anonymous online questionnaire was sent out to all the adult Hungarian ice-hockey players (population size = 1673). The questionnaire contains four parts: 1. basic data of the participant, 2. Schutte et al. (1998)'s Emotional Intelligence Scale, validly translated into Hungarian, 3. Wagnild and Young (1990)'s Resilience Scale, validly translated into Hungarian. According to the literature and hypotheses, the longer the player plays ice-hockey, the higher value he/she must reach on the emotional intelligence and resilience scales. To meet scientific standards, Cronbach's alpha will be calculated for each scale, to identify whether the scale is a reliable measurer of these abilities.

In order to accurately identify the contribution of playing ice-hockey to the two examined abilities, the sub-scales of the scales must be included in the research, in both cases. Based on the work of Lane et al. (2009), the Emotional Intelligence Scale has six subscales, with separate items loading them:

1. Appraisal of others emotions subscale, items: EI18, EI26, EI29, EI33, EI32, EI5, EI25
2. Appraisal of own emotions subscale, items: EI9, EI19, EI22, EI15, EI2
3. Regulation subscale, items: EI21, EI14, EI6, EI23, EI1
4. Social skills subscale, items: EI11, EI13, EI30, EI4, EI24
5. Utilization of emotions subscale, items: EI7, EI12, EI17, EI20, EI27, EI31, EI16
6. Optimism subscale, items: EI8, EI28, EI3, EI10

Based on the work of Fernandes et al. (2018), the Resilience Scale's subscales are the following, with the following items:

1. Meaningfulness subscale, items: RES4, RES11, RES13, RES14, RES15
2. Perseverance subscale, items: RES1, RES2, RES6, RES10, RES17, RES18, RES21, RES24
3. Self-reliance subscale, items: RES8, RES9, RES16, RES19, RES20
4. Existential aloneness subscale, items: RES3, RES5, RES22, RES23
5. Equanimity subscale, items: RES7, RES12, RES15

The research uses regression analysis, as it can reveal the causal relationship between parts of basic data and values measured by the scales used. Foster et al. (2017) claims that emotional intelligence improves when becoming older. Gooding et al. (2011) proved that older adults show higher resilience levels than the younger. In order to catch whether ice-hockey has a contribution to the abilities, a separation between the effects of playing ice-hockey and the effects of becoming older must be done. In the basic data section of the online questionnaire, the filler has to mark his/her age, and for how long has he/she been playing hockey for. Comparing the linear regression values of these two effects with the subscales of the two scales will make clear whether playing ice-hockey contributes to these abilities, or is it becoming older which makes the players improve in these abilities.

2.4 RESULTS

A total amount of 104 adult ice-hockey players participated in the research, the answer rate is equal to 6.216%. Cronbach's alpha value for the emotional intelligence scale showed a strong, .810 value, the Resilience scale showed .842 meaning both scales are reliable and usable for our research.

Emotional Intelligence Scale subscales	Years spent playing ice-hockey	Age
1. Appraisal of others emotions subscale	No linear regression model could be built.	No linear regression model could be built.

2. Appraisal of own emotions subscale	No linear regression model could be built.	No linear regression model could be built.
3. Regulation subscale	No linear regression model could be built.	Adjusted R square = 0.129 F value = 16.227 Significance = 0.000
4. Social Skills subscale	No linear regression model could be built.	No linear regression model could be built.
5. Utilization of emotions subscale	No linear regression model could be built.	No linear regression model could be built.
6. Optimism subscale	No linear regression model could be built.	Adjusted R square = .100 F value = 12.505 Significance = 0.001

Table 1. *Emotional intelligence Scale subscales linear regression models with the players' years spent playing, and age. (Source: Own creation.)*

As seen from Table 1., between the years spent in ice-hockey of players and neither of the emotional intelligence subscales could a linear regression model be built, meaning no causal relationship exists in the data between them. This means, playing ice-hockey cannot contribute to the emotional intelligence of the players. A linear regression model could be built between the age of the players, the regulation of emotions and optimism. In every other case, no regression model could be built between the values. This means the regulation of emotions of the players and the optimism are improving over time, but show no relationship with playing ice-hockey. Therefore, I reject my first hypothesis.

Resilience Scale subscales	Years spent playing ice-hockey	Age
1. Meaningfulness subscale	No linear regression model could be built.	Adjusted R square = 0.032 F value = 4.449 Significance = 0.037
2. Perseverance subscale	No linear regression model could be built.	No linear regression model could be built.

3. Self-reliance subscale	No linear regression model could be built.	No linear regression model could be built.
4. Existential aloneness subscale	Adjusted R square = 0.031 F value = 4.319 Significance = 0.040	Adjusted R square = 0.073 F value = 9.079 Significance = 0.003
5. Equanimity subscale	No linear regression model could be built.	No linear regression model could be built.

Table 2. *Resilience Scale subscales linear regression models with the players' years spent playing, and age. (Source: Own creation.)*

As seen from Table 2., in the case of Meaningfulness subscale, only with of the age of player could a model be built. A linear regression model could be built between years spent playing ice-hockey, and Existential aloneness subscale value. However, a stronger causal relationship was found between the age of the player and the subscale. This means resilience abilities improve when becoming older, and as the model was weaker in the case of years spent playing ice-hockey, this result suggests that this improvement is more likely to be caused by ageing, and only partially by playing ice-hockey. In every other case, no regression model could be built. Therefore, playing ice-hockey may contribute to the resilience ability of the players, as the improvement is more likely to be caused by becoming older. Experts of sport psychology suggested however the linear regression model could be built between time spent playing ice-hockey and existential aloneness values, their experience suggest that the improvement effect is more likely to be caused by becoming older, and an interdependence is present between age and time spent playing ice-hockey. Therefore, reject my second hypothesis.

2.5 DISCUSSION, LIMITATIONS AND FUTURE OF RESEARCH

In this research, the author seeks for the answer of the question whether playing ice-hockey can contribute to the emotional intelligence and resilience abilities of people, so whether managers in companies can use playing ice-hockey as a training method to contribute to the two mentioned abilities of the employees, and increase the psychological capital of their companies. The results revealed that playing ice-hockey cannot contribute to emotional intelligence and resilience abilities of the players, as the improvement is stronger connected to the age of the players, than their time spent playing ice-hockey. This means companies now must find another

method to use instead of sending their employees to play ice-hockey, and hire older employees if they want to increase the psychological capital of their companies, and gain competitive edge over their competitors (Luthans et al. (2007)). It is also important to mention that encouraging employees to play ice-hockey may support the employee's healthy work-life balance, and based on the literature, does help the employees to successfully learn coping strategies against stress and anxiety (Kaplánová (2019), Grakauskas and Valickas (2006), Battochio and Stambulova (2019)). The limit of the research is mostly it's cross-sectional design, the low rate of answers, and the fact that it is very hard to separate the effect of playing ice-hockey and becoming older in the two measured abilities, as the older the player is, the more time he/she could spend playing this sport. This interdependence limits the research. Further, longitudinal research with higher representativity is required to measure if such an increasing effect exists in playing different sports. Still, the research focused on the psychological capital increasement option, so whether it is a good decision for companies to hire ice-hockey players, or purposely send them to play this sport. Though the results showed that this increasement is more likely to be caused by becoming older, the literature suggests that playing ice-hockey does contribute a lot to its players life, maybe even in emotional intelligence, and resilience.

ACKNOWLEDGEMENT: The authors are thankful to all the participants of the research: the players and the professionals.

3. CHAPTER: RESEARCH DESIGN FOR DEVELOPING AND VALIDATING ICE-HOCKEY TEAM DIAGNOSTICS SCALE

Reference: Géczi, G. (2021a) 'Research Design for Developing and Validating Ice Hockey Team Diagnostics Scale', *International Journal of Sport and Health Sciences,* volume 15(8) [online]. Available at: https://publications.waset.org/10012179/pdf (Accessed: 2021. 09. 01)

ABSTRACT

In the modern world, ice-hockey (and in a broader sense, team sports) is becoming an increasingly popular field of entertainment. Although the main element is most likely perceived as the show itself, winning is an inevitable part of the successful operation of any sports team. In this paper, the author creates a research design allowing to develop and validate an ice-hockey team-focused diagnostics scale, which enables researchers and practitioners to identify the problems associated with underperforming teams. The construction of the scale starts with personal interviews with experts of the field, carefully chosen from Hungarian ice-hockey sector. Based on the interviews, the author is shown to be in the position to create the categories and the relevant items for the scale. When constructed, the next step is the validation process on a Hungarian sample. Data for validation are acquired through reaching the licensed database of the Hungarian Ice-Hockey Federation involving Hungarian ice-hockey coaches and players. The Ice-Hockey Team Diagnostics Scale is to be created to orientate practitioners in understanding both effective and underperforming team work.

Keywords—Diagnostics Scale, effective versus underperforming team work, ice-hockey, research design.

3.1 INTRODUCTION

Ice-hockey is a fun activity that may offer its players plenty of joyful, emotionally uplifting and real-life experiences. Both its complexity and the speed in ice-hockey are outstanding features compared with other team sports. Thus, researching phenomena in ice-hockey offer a great

chance to the author to create a scale, which both academics and practitioners may find useful when dealing with parameters of team efficiency, and especially with underperforming teams. Based on early consultations with experts of the field, underperforming is quite strongly influenced by the coach's or manager's expectations, therefore, the main target of constructing such a scale is to collect and create the most objective, and commonly accepted factors that work well in the operation of a highly functioning team. When we know which important factors must be measured in a team, we may create the items of the scale to successfully identify the underlying, and mostly non-visible causes of the underperformance.

As the nature of performance of a team may only be seen by professionals around the team, the results of the game may be an aid to help better understand the level of performance that can be classified as sufficient or insufficient. A performance which is not sufficient is underperformance in the author's concept, and must be evaluated with the help of the Ice-Hockey Team Diagnostics Scale (IHTDS).

3.2 LITERATURE REVIEW

Tomaszewski, Zaretsky and Gonzales (2020) offers a reliable starting point for qualitative research, as it compares four main types of qualitative research design: case study, ethnography, narrative and phenomenology. Each design has its own strength and weakness, subject to the different foci. For the purpose of constructing and validating the scale, the phenomenology design is proved to be the most suitable one as it explores the experience of the experts who are going to help the author to construct the categories and the items for the scale. Trotter (2012) deals with the problem of qualitative researches from a sample design and sample size point of view. It suggests when designing researches containing qualitative and quantitative methods, targeted sampling method is most capable to ensure the validity of the research. Crowley, Van der Merwe and Skinner (2020) used interpretive phenomenology and focus group interviews in order to measure adolescent HIV self-management in South African environment. The research design contained three major steps: firstly, making interviews and focus groups using interpretive phenomenology, secondly, triangulation of literature, theory and qualitative data, thirdly, item validation and refining using cognitive interviewing. The importance of this method for the current paper is that phenomenology can be used as an approach when qualitatively obtaining information through interviews. Bevan (2014) offers a method description for phenomenological interviewing. The author of the present paper learnt from the

literature that interview questions should be asked in a way such that the interviewees present state rather than their past state be addressed.

Collins and Durand-Bush (2016) examined the roles a coach must be willing to play in order to successfully optimize team functioning in curling, namely: technical/tactical specialist, mediator, manager, facilitator and motivator. These roles may be used in the proposed model of team functioning. Gómez et al. (2021) examined how elite soccer team's performance changes when the coach is replaced mid-season. In the linear regression analysis, the research focused on four variables of the coach's operation and environment: experience of the coach, budget of the team, and whether the coach was a former elite player, and whether the coach was a novice or had experience. In the used model, performance is equal to summing up the four variables, adding intercept and disturbance term. The results: 1. A team's short-term performance increased significantly after the coach replacement; however, this effect declines on the long-term and 2. This winning effect has no connection with the coach-related factors mentioned earlier, suggest that the stimulus a team receives when the coach is replaced may motivate the players to play their bests, and the knowledge of the coach does not play a crucial role in the success of the team. When researching elite-level players of soccer, it is reasonable to assume that they all possess a high level of knowledge about the game, and this fact decreases the team's need for high level knowledge of the coach. Also, elite soccer is much more optimized and advanced both in theory and practice as elite ice-hockey does, and the variables the research uses are limited to only 3 factors (experience, former player and novice in the league), as if these would perfectly explain the coach's operation when coaching a new team. Therefore, the author questions the applicability of these findings in ice-hockey, and the proposed model for building and constructing the IHTDS. Salman, Arnesson and Shukur (2009) studied six Swedish elite league teams with the data of 21 years (1975-2006) in order to better understand how the performance of the team relates to key variables like coaching experience and coaching ability. It found that coaching ability is strongly correlated to team performance, and that managerial succession has a significant negative effect on team performance. As the results for the six teams differed, it is reasonable to assume that there is no strict formula that works the same in every team – the coach must be flexible and must fit into the operation of the team in order to achieve great results, and make the team high performing. However, in all the six cases, the coaching ability was strongly correlated to team success (0.77, 0.74, 0.75, 0.72, 0.75, 0.73). This means coaching ability must be included in the IHTDS scale. The study does

not specify what sub-variables sum up as coaching ability, the author of the current paper considers the most detailed model is found in Collins and Durand-Bush, 2016.

Moll and Davies (2021) examined how soccer players perform when receiving feedback from a coach expressing different emotions: pride, happiness, neutral and shame. In the results, it was concluded that when the player and the coach have a close relationship, the expression of different emotions by the coach influenced the performance of the player. Although the players could only weakly distinguish pride and happiness expressed by the coach, they showed increased performance while no performance increasement was found when the coach expressed shame when giving feedback. These results suggest that the utilization of emotions – which is a subscale of The Emotional Intelligence Scale – is an unmissable element of any model describing a team's performance where the coach is included as well (Lane et al., 2009).

You (2020) examined the cultural differences between high and low performance Korean university soccer teams, with using The Organizational Culture Assessment Questionnaire. The questionnaire measures four main factors of culture: 1. managing change, 2. achieving goals, 3. coordinated teamwork, 4. cultural strength. As a result of the research, significant differences were found between high- and low-performing teams in factors 1, 2, and 4, meaning culture is strongly related to the performance of a soccer team. Although the results show relationship, it remains unclear whether the culture causes the higher performance of a team, or high performance causes the culture to be more developed inside the team. As no regression analysis was made, finding the place of culture factor in the model creation needs further reading in the topic. Arnold, Fletcher and Daniels (2017) carried out a throughout regression analysis when examining organizational stressors, coping and outcomes in competitive sports. As a result, the regression model values were calculated between variables team & culture frequency and duration, and performance satisfaction. The beta values of the models were -.042 and -.045, meaning the team & culture stimuli has a slight negative effect on the performance satisfaction of the athletes. Although the results are statistically significant, the sample in the research contained team sport players and individual athletes as well, making the results questionable from the author's perspective. The Organizational Cultural Assessment Questionnaire is usable when measuring cultural factors in teams (Sashkin, 2001). Pitts and Evans (2020) analysed the data of National Football League in the time period of 1970-2017 in order to measure the head coach's and the defensive coordinator's effect on the defensive performance of their teams. The research constructed a regression model, including team and league characteristics (offensive

and defensive performance, player experience and player quality, defensive alignment), defensive coordinator and head coach characteristics (coach's tenure with the team, coach's background, internally promoted coach or an external hire) along with their individual effect on defensive performance. It was found that only in around 10% of the cases a significant effect could be measured in case of defensive coordinators, and a low 11% could be proven in case of head coaches. As the players of the NFL league are known to be the best players of the world playing American football, the role of a coach and a defensive coordinator might play a slighter role in the performance of the team, meaning the findings of the study must be used cautiously in the model building process. As the validation of the IHTDS scale is planned to be made on Hungarian data, it is mandatory to consider the differences of Hungarian and top-level leagues, such as NFL in American football. In the highest-level Hungarian ice-hockey league, the pool of players is much more limited, and the players might require the coach to be more involved in the performance of the team. Therefore, the author keeps the coach's involvement in the performance of the team as a factor to use in the proposed model. Keatlholetswe and Malete (2019) used regression analysis in order to measure the causal relationship between coaching efficacy and coaching behaviours on the outcomes of the functioning of Botswana Premier League soccer teams. For the analysis, it used multiple scales. Out of four, only the Game Strategy Efficacy subscale of Coaching Efficacy Scale had a significant effect on team atmosphere and performance. This phenomenon is explained with the fact that the Botswanan Premier League is very far from being a totally professional league, and the training hours of the players are limited to an average of 7.5 hours a week, and the teams are partly managed by volunteers. The findings support the author in the model building with empowering the idea that the involvement of the coach in the performance process can be different when examining multiple teams. Revised Leadership Scale for Sport and Coaching Efficacy Scale is an instrument that may be capable of be used in the model building (Zhang, Jensen and Mann, 1997; Feltz et al., 1999). Zavartiaeva, Naidenova and Parshakov (2018) analysed the effect of the coach's overconfidence and the team performance, with a regression analysis-based research design. According to the results, opposed to the preliminary ideas, the coach's overconfidence was not affecting the number of scored and allowed goals, but an overconfident coach might motivate the players better than a coach with average confidence. As the motivation of the players might play an important factor in their team's performance outcomes,

further reading must be done regarding motivation & team performance in order to successfully build motivation into the proposed model.

Durovic, Veljkovic and Petrovic (2020) studied the importance of motivation in sport context, from a psychological point of view. It emphasizes the role of the coach in the motivation process and identifies motivation as the key element for sports achievement. As achievement in professional sports is mainly acquired through results, and result is the most important measure of the performance of a team, the author assumes that the coach's ability to motivate and the player's intrinsic motivation are important factors when dealing with team performance. Gramacy, Jensen and Taddy (2013) offers a great insight how deeply ice hockey can be analysed through the statistical data available in a top-tier league like the National Hockey League (NHL). It used regularized logistic regression modelling to accurately measure an individual player's contribution to goal scoring. As the used statistical method is quite advanced and deep knowledge is needed when using, the author questions the usability of their model in the proposed model building. Although the regression model will not be built in the current paper's proposed model, the authors wrote: "The popularity of traditional plus-minus is informative: player ability can be measured from the subset of events that actually lead to goals" (Gramacy, Jensen and Taddy, 2013). Therefore, plus-minus data can be used as a measure in the upcoming model. Riley (2017) used structural equation modelling with the aim to better understand the nature of ice-hockey. Two structural equation models were used, in which latent variables were offense, defence and possession. According to the results, the latent variables are best understood if a small number of measured variables were used and offense mediates the relationship between defence and possession. One major contribution is present to the current research: however complex ice-hockey is, simple measures are used to record individual and team performance, and the author should not fall into the mistake to overcomplicate the proposed model. Okamoto (2011) analysed the odds ratio of NBA superstar Kobe Bryant, and how his performance related to the success of his team, based on plus-minus as an independent, with team wins/losses as the dependent variable. In the findings, it is stated that playing in the home court may have an effect on the performance. The research offers a great method to better understand how individual performance is related to team performance, with the method of creating a matrix in which team wins and losses are the y axis, while individual player's plus-minus data are on the x axis. With this method, players' competitive characteristics are well

definable, along with their contribution to team performance. The author considers this method as a useful and usable part of the proposed model.

Glavas (2020) examined the effect of cognitive abilities of players on their performance in soccer. Basic cognitive abilities of the adolescent players were measured using Corsi block and concentration grid tasks, and their soccer performance was measured through five soccer skills – tactical ability, technical skills, physical ability, mental toughness and situational awareness. As a result, visuospatial capacity was found to have a significant effect on the soccer performance of the players. As adolescents were the participants of the research (age mean: 16,5, SD: 1,13), further reading is required to understand whether visuospatial capacity decreases as people become older. Wang, Infurna and Schaefer (2020) examined how visuospatial performance predicts motor learning in older adults. They found that higher-level visuospatial functioning caused the increasement in performance, meaning that visuospatial ability is not only possessed by children, but may be used with adults as well when identifying factors that may cause an individual's, and a team's performance. Therefore, visuospatial functioning may be used in the proposed model building.

Géczi and Komlósi (2020) tested the hypotheses whether playing ice-hockey helps its players to improve their emotional intelligence and resilience abilities. According to the linear regression analyses, playing ice-hockey does not improve the emotional intelligence, and only has a slight effect on the resilience level of their players, however, the older the player is, the better it is in these abilities. Therefore, the age of the player must be a powerful factor in the model, and not the ages spent playing ice-hockey. The contradiction in this question can be assessed with the help of convertible knowledge. The more convertible knowledge the player has from different areas of life, the better chances it has when scoring opportunities arise. Therefore, further reading is required in this topic, in the field of convertible knowledge and collective intelligence. Bates and Gupta (2016) examined in three studies how individual IQ's and collective intelligence are related, with using regression analyses and structural equation modelling. It was found that group IQ can be caused with 100% by individual IQ ability levels. This means the cognitive ability of people has no synergic effect when working together, so the emerging ability which the current research is partly aiming for must be found somewhere else in a human's operation. Verhoef (2017) dealt with the question of faith and belief, how they are connected and concluded that nor belief nor faith should stand alone, and mentioned Binswanger's phenomenology of love. Although this field seems far from the literature

processed previously, human factor is present in the operation of an ice-hockey team, love is an inevitable phenomenon for the model building. Szemes et al. (2017) examined the age-related differences in motivational climate and extrinsic-intrinsic motivational factors, with data of Hungarian national wrestling teams. It concluded that amotivation shows a descending pattern when becoming older. Motivation may play an important role in the proposed model. "Hockey Confidence Survey" was provided to the author, which may be used as a measurement instrument in the proposed model (Feltz et al., 1999).

Lee et al. (2014) examined the effect of non-linear pedagogy compared to linear pedagogy to better understand what non-linearity in pedagogy causes to athlete's performance. The researchers experimented with tennis players, measuring their hit accuracy and movement clusterability. It was found that linear and non-linear pedagogy both increased the hit accuracy, but the non-linear teaching method increased the number of clusters of movements, therefore, offered a greater variability in movement toolbox. However, this does not mean non-linear teaching method is superior to linear. As the aim of this paper is to build the proposed model and prepare the author for constructing and validating the IHTDS scale, the pedagogical linearity vs non-linearity must be a factor in the model as part of the coach's operation. If the coach wants to have the players behave and move the same way, linear methods are to be used, while if the coach wants diversity and colourfulness, non-linear pedagogical methods are effective.

3.3 MODEL CREATION

In order to be successful in the interviews with the experts of the field, a proposed model must be created by the author to serve as the base of the interviews. According to the literature and the knowledge obtained from the experts, the proposed model for constructing the scale is seen in Fig. 1.

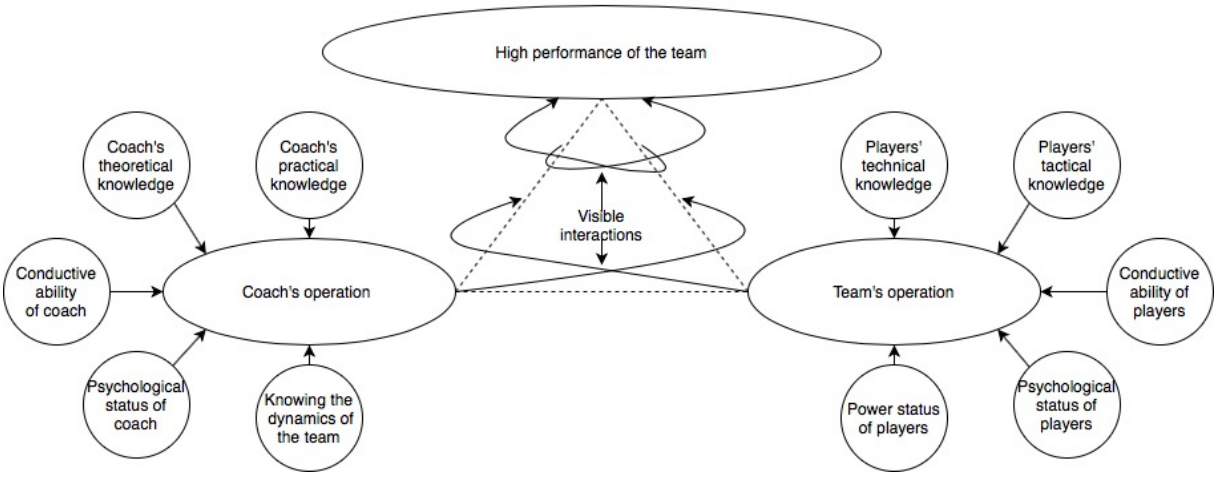

Figure 1. *Proposed model of ice-hockey team performance. Source: own creation*

The coach's practical knowledge comes from experience from coaching, and other sources of practical knowledge. The most ideal case is when the coach has convertible knowledge that it can be converted to ice-hockey as well. The same is the case with the coach's theoretical knowledge. Connected to psychology, the optimal charging of positive and negative feedbacks in the coach-player relationship is capable of reaching the state in which the player can optimally perform. The knowledge and experience of the coach plays a crucial role in this process. The best case is, when a coach has transdisciplinary knowledge. According to the transdisciplinary model, knowledge is neither interior nor exterior (Nicolescu, 2006). The conductive ability of the coach started as leadership ability when the author started to build the model. Leadership would meet the traditional standards better, but the phenomena when a coach influences the players to perform better are more likely to be explained by conductive influence. The conductive ability is to manage the energy flow in the players both by emotions and thoughts. In the proposed model, the conductive interactions work both ways, as the players may influence the coach as well. The psychological status of the coach is important, as the more problems the coach faces, the less likely for it to find the best possible solutions. Knowing the dynamics of the team is mostly the history of the team, as many conflicts and non-understandable phenomena gain significance when the coach knows the story behind.

The player's technical knowledge plays an important role in the performance of the team, as without high-level technical abilities, the team will play under its full potential. The same applies for the tactical knowledge of the players. Once again, transdisciplinary knowledge is the aim for the players as well. The conductive ability of the players is also required for high-

performing teams, as in many cases, the players must influence the coach in order to make the team high-performing. The conductive ability of the players started as followership ability when the author started to build the model. Followership is widely used in the literature, although the influence the players make on the coach is more understandable with the use of conductive influence. The psychological status of the players is important as well, the better status they are in, the higher they can perform. The power status of the players has multiple meanings: firstly, their power and endurance, secondly their power position inside the team.

When the cooperation of the coach and the players starts, the peers start to work in their own way, both working for the performance of the team. Their orbits cross each other, making a visible interaction arise. There the conductive ability is used the most, as both peers do their bests to merge the orbits. Assuming that the coach and the players are at the same level in conductive ability, both continue their own orbits. As the model indicates, the orbits go behind the triangle, representing the observer in the model. Behind it, the orbits cross each other as well, where non-visible interactions happen. Once again if the team and the coach continue their own process, they will have more interactions that are visible, and it goes on and on until the high performance happens. The proposed model has a universality claim.

3.4 RESEARCH QUESTIONS AND HYPOTHESES

The observer can create and apply specific models that help to see through and understand diverse problems in ordered thought structures, done by interpreting the connection between concepts, processes, states, positions, cooperations, and inter-dependencies. It is also a basic assumption that beyond the individual level of the study, the operation of the team with emergent characteristics allows for team-level interpretation or analysis. The meaning of the whole is more than the sum of the meanings of the parts.

As the proposed model serves as a base of the interviews, we are determined to base the research questions and hypotheses on it as well. As the aim of the study is to build the highest-level research design for building and validating the IHTDS scale, the components of the model must be focused on in the research questions and hypotheses.

- RQ1: Are the five factors of the coach's operation relevant and sufficient for understanding the complex operation of a coach?
- H1: The author assumes that the five factors of the proposed model are relevant and sufficient for understanding the complex operation of a coach.

- RQ2: Are the five factors of the team's operation relevant and sufficient for understanding the complex operation of the team?
- H2: The author assumes that the five factors of the proposed model are relevant and sufficient for understanding the complex operation of a team.
- RQ3: How does visible and non-visible interactions arise in the cooperation of coach and players?
- H3: In the cooperation of coach and players, visible and non-visible interactions turn into practice that supports high performance of the team.
- RQ4: How does the cooperation of the coach and the team function as a system that supports high performance?
- H4: The coach's and the players' cooperation build up a balanced system, which supports the highest possible performance.

3.5 METHODS

The proposed model is going to be tested through a two-step method: firstly, interviews with experts of the field are going to be carried out in order to finalize the proposed model. Secondly, the IHTDS scale is going to be constructed based on the final model and evaluated with a statistical process. Fülöp and Takács (2013) used principal component analysis when creating the scale for the study. An important and unique characteristic of the current study is that the proposed model is highly based on theoretical background, and the factors influencing the performance of the team are identified, therefore, a Confirmatory Factor Analysis is going to be carried out to test the fit of the final model on data, with SPSS version 24.0 software (Chicago, SPSS Inc.) (Hoyle, 2012). The items for the scale are going to be created when the final model is ready, and the factors serve as subscales. The future user of the scale will want a clear identification about the cause(s) of underperformance. As the final model serves as the base of the scale, the model itself must be included in the use of the scale, with proper, understandable explanation. When the user of the scale has a proper understanding of the model, the results of filling the scale will be meaningful.

The author is going to perform structured interviews with 15 experts of Hungarian ice-hockey, including 5 senior national team players, 5 national team coaches and 5 national team leaders. The structured interviews offer a great chance to improve the proposed model, and to find the hidden connections among the factors, and to test whether the five factors of coach's, and

players' operation covers the whole ice hockey team's operation. Therefore, the following interview questions arise:

1) According to your experiences, how would you describe the relationship between the coach's practical knowledge and team performance?

2) According to your experiences, how would you describe the relationship between the coach's theoretical knowledge and team performance?

3) According to your experiences, how would you describe the relationship between the conductive ability of the coach and team performance?

4) According to your experiences, how would you describe the relationship between the psychological status of the coach and team performance?

5) According to your experiences, how would you describe the relationship between knowing the dynamics of the team and team performance?

6) Do you think the five mentioned factors cover the whole operation of a coach?

7) If not, what would you add to the model?

8) According to your experiences, how would you describe the relationship between player's technical knowledge and team performance?

9) According to your experiences, how would you describe the relationship between player's tactical knowledge and team performance?

10) According to your experiences, how would you describe the relationship between conductive ability of players and team performance?

11) According to your experiences, how would you describe the relationship between psychological status of players and team performance?

12) According to your experiences, how would you describe the relationship between power status of players and team performance?

13) Do you think the five mentioned factors cover the whole operation of a team?

14) If not, what would you add to the model?

15) According to your experiences, should the coach and the players have visible and non-visible interactions in order to perform well?

16) According to your experiences, when the coach and the players acts as two opposing objects in the same team, do they perform well?

17) According to your experiences, when the coach and the players keeps their orbits and the system is balanced, does it support high performance?

18) Do you think the model describes the operation of a high-performing team?

19) If not, what would you add to the model?

The data for the CFA analysis are going to be gathered from the Hungarian first league teams. All of the Hungarian professional players, and all of the Hungarian elite-level coaches will be included in the research, in the direction of making it as representative as possible. The questionnaire is going to use Likert-scale, scaling from 1 to 6.

3.6 DISCUSSION

Many of sport teams, including ice-hockey teams, face the phenomenon of underperformance, as it is human beings who are playing the games. Various factors are influencing how they perform. We read the most recent literature with the aim of creating a model that would explain and help academics and practitioners to gain understanding why underperformance happens. As a consequence, if the main factors of performance are well known by the experts, underperformance can be understood and actions may be taken in order to dissolve the cause behind it. Although the paper aims at dissolving the cause of underperformance, a high-performance team with the knowledge contained in the current paper may further improve its performance as well, by having a competitive edge over the competitors. The proposed model and its qualitative and quantitative testing are an adequate background for gaining such a competitive edge, which may add novelty to the ever-growing scientific knowledge-domain and professional practice.

3.7 CONCLUSIONS AND LIMITATIONS

Many reasons might be present for a researcher to conduct a research. The most important reason for the author is to add a valuable instrument to the knowledge base of sport science. We conclude that theoretical model building is an important activity when conducting a research, as theoretical and practical knowledge is becoming more useful when both are acquired, and the transfer is available from theory to practice and vice versa. The future of society depends on people who have this ability.

As the type of the current study is research design, the proposed model has not been tested either by interviews or by statistical analysis. The author is convinced that a theory-driven approach and testing in practice constitute a trustworthy future for scientific research.

4. CHAPTER: ANTIFRAGILE APPROACH FOR ICE-HOCKEY TEAM PERFORMANCE MODELING: THE DEFINITIONS COMPONENT

Reference: Géczi, G. (2021b) 'Antifragile Approach for Ice-Hockey Team Performance Modeling: The Definitions Component' *12th IEEE International Conference on Cognitive Infocommunications: Proceedings*, Győr, 23-24-25 September 2021.

ABSTRACT

Antifragile operation of a system depends on the structure it is built upon. The paper presents definitions upon which a model of ice-hockey team performance lies, thus providing the robustness to the system, next to a human factor responsible for getting the needed stimuli to evolve towards antifragile operation. The author collected six definitions for each of the factors of the model, and created his own definitions providing the supporting pillars of the evolving system. It is concluded that the robustness of the system, backed up by the definitions component, is expected to give birth to an emergent state in which the balance between team cohesion and openness is found by the team as a whole supporting antifragile operation.

Keywords—antifragility; definitions; ice-hockey performance modeling.

4.1 INTRODUCTION

Every model created by researchers contributes to the ever-growing scientific knowledge base, but their use in practice may strongly lie in the components they are built upon. A strong, all-compassing definitions component is capable of making the model evolve towards antifragility. Antifragility is defined as the ability to strengthen by the impact of stressors (Taleb, 2012a). In the 21st century, with a high number of stimuli every system must face, making a system antifragile is a viable way of ensuring its development. Not every system is capable of being transformed to be antifragile, although the author's basic assumption is that the natural evolution of systems may all lead to antifragile operation.

White (2013) considers banking system as "not naturally fragile". While such an enormous system has the capability of reacting to stressors with empowerment, a model backed up with a proper definitions component must also be capable of this operation. As among the

characteristics of these systems one decisive factor is found – in the case of banking systems the managers, in the case of models the researchers – it is the activity of these human factors that will ensure the evolution of the systems towards an antifragile operation. Although the natural evolution is evolving towards antifragility, decisions made by the human factor may have a hindering or a fostering effect on the evolution process. The environment, in which these systems operate, be they legal or business environments, are playing a crucial role when considering antifragile operation, as most of the systems operate in an environment that presents rules for the system itself. The size of the system – and, therefore, the number of components – determines the speed with which the system can answer to the changes of environment. It is assumed that the higher rate of human involvement present in the system, the more antifragile it is. In the example of the banking system case, the more the components are interdependent inside the system, the more fragile the system is. One component's loss may cause other components to be lost as well. If the interdependence is high, it is more likely that antifragility sets in. For example, if a lizard has its tail connected mechanically to its organs, then the loss of its tail causes a more severe impact to the whole organism. Therefore, the less interdependence is present between the components of the system, the more antifragile it is. However, the more components a system has, the more likely it is that some of them will be lost, possibly at the same time. A harmony must be present in the system, balancing the number of components and their interdependence to ensure the dynamics of the evolution.

Learning is an important activity of the human factor when building a system towards antifragility, as it is in the case of algorithms learning how to efficiently cover a building with 5G signal (Makara and Csurgai-Horváth, 2021). In the case of human beings, several psychological processes influence how efficiently they communicate. As discussed above, it is the human factor that makes the systems less fragile, through its openness function. Human factor in any evolving system helps the system to acquire the necessary variance, including the needed stimuli. Computers are capable of providing a reliable performance, supporting the human factor (Ujbágyi et al., 2020).

Theoretical models are more prone to environmental factors, and they have a potential to represent the robustness attribute in the system. Therefore, a system containing a robust model, along with a human factor providing the needed variance, may evolve towards an antifragile operation. The robustness – as a starting criterion towards evolution - of the model is highly dependent on the supporting definitions component. The clear definitions offer the opportunity

to enhance the robustness of the author's model of ice-hockey team performance. Antifragility of the system is acquired through self-organization towards a state in which the system is robust, and evolvable (Kim et al., 2020). The elements of the system are required to interact a way that enables to give birth to emergent abilities that leads to the highest possible performance. The definitions component is able to contribute to this phenomenon by strengthening the robustness characteristic of the system.

4.2 DEFINING THE FACTORS OF THE MODEL

The model contains three participants cooperating towards high ice-hockey performance: the coach, the team and the observer. Five important factors are covering its operation: practical knowledge, theoretical knowledge, conductive ability, psychological status and knowing the dynamics of the team. The team has also five factors that covers its operation in the author's model: players' technical knowledge, players' tactical knowledge, conductive ability of players, psychological status of players and power status of players. The coach and the team are working together and interactions happen as both are moving towards high performance, fully keeping their identities along on the orbit.

As mentioned earlier, the robustness of the model and the antifragile system is ensured by the definitions component supporting it. The factors are created to cover the operation of an ice-hockey team from a performance perspective. The concept is built up from definitions of the factors, providing the robustness, and the boundaries of the model. The author presents six definitions based on the found literature together with his own definitions for every factor in order to ensure that the factors are well described, ensuring the model's usability in practical context as well.

4.2.1 FIRST FACTOR: COACH'S PRACTICAL KNOWLEDGE

Dorgo (2009) identifies a coach's practical knowledge as "knowing-how, which involves the actual disposition to be able to do things with intelligence, and is an expression of rational practice. This knowledge is usually not conscious and is used to comprehend situations and cope with difficulties. Also, this form of knowledge is acquired through action and is highly dependent on the individual's coaching experience". In the evolvement process, a system is only viable to survive if continuous impulses are reaching the boundaries of the system. To

supply these impulses to make the system strengthen, ongoing development is needed by the human factor, through practical coaching activity as a source of new practical knowledge. If the human factor develops, the robust model is improved as well. This development is likely to happen in bigger phases than in the case of human factor.

Jones, Armour and Potrac (2003) explains: "the practical experience of coaches may be stored in the form of contextualized directories of diagnostics and operational acts. These directories help make complex situations meaningful and permit appropriate actions following the immediate recognition of situations by analogy with past experiences". The more automatically the human factor operates in practical work environment, the more capacity it has to oversee the processes adjacent. Therefore, with complexity developing slowly, the human factor is capable of outgrowing it and liberate the capacity to increase the quality of its operation, which is based on practical knowledge.

Mesquite et al. (2014) focuses on the learning process when defining coach's practical knowledge. It states that the coach's practical knowledge is the result of "a learning process of the coach that is developed by ongoing interactions with specific individuals within practical coaching contexts". Ongoing interactions are inevitable in the operation of an antifragile system, based on its openness. The characteristic of a closed system is that it has to be defended to ensure its survival by either the human factor or from outside forces. Meanwhile, open systems are more likely to evolve. Development is possible in the case of closed systems as well, emphasizing the development of the human factor. Closed systems do not respond to outer stimuli, making antifragility unreachable. Therefore, the author's antifragile system is by definition an open system, in which interactions are present to ensure its survival through evolvement.

Saury and Durand (1998) defines personal practical knowledge as "a knowledge that is tightly linked to experience, context dependent and difficult to verbalize." A practical knowledge that lies upon experience is owned by the human factor and may make its way into the robust model as well.

Guzman (2009) defines this knowledge as "the blend of explicit and tacit procedural knowledge with explicit and tacit practice." Procedural knowledge which is applied in practical context is likely to obtain positive, or negative feedbacks from the environment. These feedbacks are processed by the human factor, and the knowledge is modified based on the nature of the

feedback. It is not only the quantity, but also the quality of the feedbacks that makes the human factor change in the knowledge. The change might have an effect on the robust model as well. Driel, Beijaard and Verloop (2001) identifies practical knowledge as one which is "conceptualized as action-oriented and person-bound, and it integrates experiential knowledge, formal knowledge and personal beliefs." Once again, the openness of the system is a key element, as action-orientedness requires interactions with the environment of the system. Human factor plays an important role in this process, as it is capable of acquiring practical knowledge.

Most of the definitions mentioned highlight the connectedness of practical knowledge and experience in coaching context, while knowledge of the game is acquired from being an athlete as well, contributing to the practical knowledge of the coach. Therefore, the author's own definition for the coach's practical knowledge is the following: A knowledge is categorized as coach's practical knowledge if it comes from the coach's experience in doing sports and coaching activity.

4.2.2 SECOND FACTOR: COACH'S THEORETICAL KNOWLEDGE

Hatlevik (2011) offers a general definition of what theoretical knowledge is – "a knowledge that has been acquired in an education program to a workplace setting." Education programs are among the best options to gather new knowledge contributing to the operation of the coach. The human factor of the system may face an enormous amount of new knowledge, which can modify the operation of the human factors and may have an effect on the to-be robust model as well.

Mavvidis, Sdoukos and Ziagkas (2018) presents categories which are all included in a tennis coach's theoretical knowledge: "technique, tactics, teaching-coaching, rules and racket." Theoretical knowledge by its nature is a verbalizable knowledge, which is easily exchanged with the environment. It is capable of making huge changes in the system even at the model level as exchanging big amounts of knowledge means much stimuli. Therefore, the coach exchanging much theoretical knowledge may help to create the needed interactions between the elements of the system, towards the emergent antifragility characteristic.

Klausen and Petersen (2021) offers a deeply philosophical description of theoretical knowledge. It states that it is not necessarily knowing-that; rather it is knowledge of general principles or higher-order knowledge. The main characteristic of theoretical knowledge is its

indirectness. The indirectness makes this knowledge harder to process and implement in practice, therefore, the system must balance the amount of theoretical knowledge exchanged, as processing and implementing a huge amount of information might require too much of the systems energy, making it evolving under its potential. In ice-hockey, underperformance happens if the balance of the model is not ensured, and the coach is mainly responsible for finding the way back to high performance.

Vikhman (2020) defines theoretical knowledge as the knowledge that is generated in a scientific environment, and is affected by the researcher's reflections. The system is capable of acquiring new knowledge which is to be implemented in practice. A coach constantly learning may cause the team to develop as well, maintaining balance between the coach and the team.

Alligood (2011) offers a throughout definition of what theoretical knowledge is: "a knowledge that has powerful contributions to education, research, administration and professional practice by guiding thought and action." Through raising the level of theoretical knowledge of the coach, a modified model may be formulated through an integration process.

Robertson (2003) offers a short definition: "a knowledge learned during coach education courses." The coach attending education courses might acquire the needed stimuli for the system to evolve.

The definitions of the literature processed suggest that theoretical knowledge is connected to education programs, therefore, the author's definition for this factor is the following: a knowledge is categorized as coach's theoretical knowledge if the knowledge comes from coach education programs and it guides the activity of the coach.

4.2.3 THIRD AND EIGTH FACTORS: CONDUCTIVE ABILITY OF COACH AND PLAYERS

Che, Cagin and Goddard III (2000) suggests that thermal conductivity is "a mechanism based on Fourier's law which enables the transmission of heat between objects." In order to let the system be open and communicate with its environment, a common language is needed to ensure the meaningfulness of the communication. Thermal conductivity represents transferability of emotions in this common language.

Lloyd-Hughes and Jeon (2012) defines complex conductivity as "the response of a material to an electromagnetic wave", in which permeability is a key factor. In the model, the coach and the team are assumed to be equally skilled as it supports the highest antifragile operation.

Kinaci, Haskins and Cagin (2018) offers the definition of thermal conductivity as a characteristic of a matter that highly depends on the heat current. The amount of conductive power the coach and the team has determines the inner variance of the system, whether the conflicts between the coach and the team are weak or strong. The inner variance of the system and the variance from outside elements are to be harmonized by the coach, otherwise the cumulated variance may hinder the evolvement of the system. Once again, in the case of an ice-hockey team, results are considered to be the main measure of performance. Although the evolution of the whole system may produce temporal underperformances. The coach owning the ability to positively influence the emotions of the players and vice versa is a key characteristic of a high-performing team.

Nielen et al. (1992) proposes electrical conductivity as an attribute of a material "measuring its resistance to an electric current." In the common language used by the system, electric conductivity is analogous with the transfer of thinking patterns.

Chiarello and Zinno (2005) defines electric conductivity as an attribute of material which is strongly connected to the movement of free electrons. The openness of the system enables the penetration of new thinking patterns, which may push the system towards an antifragile operation.

The author's own definition for the factor conductive ability of coach/players – adopting the metaphor of material conductivity - is the following: an ability is categorized as conductive ability of the coach/players if this ability is used when transferring thoughts or emotions to the players and coach and other potential (decisive) participants, through interactions.

4.2.4 FOURTH AND NINTH FACTORS: PSYCHOLOGICAL STATUS OF COACH AND PLAYERS

Hosseinzadeh et al. (2021) defines the psychological status as the existence or absence of psychological symptoms existing in people's operation. The stimuli for the evolvement of the system are represented in this factor. The appropriate stimuli, be it from outer or inner sources, may push the system into the state in which the emergent antifragile characteristic arises. In the case of an ice-hockey team, the common language is performance. Therefore, if the participants are all working together towards antifragility, the emergent state happens and antifragility arises from the interaction of elements. As human factor has inner variance as well, the more robust

the model is, the bigger variance is allowed for the human factor without hindering the evolvement of the system.

Gontarev et al. (2020) identifies it as the following: “the status of a person’s image of wellbeing and the existence of meaningful personal relationships.” The high-quality interactions between the elements offer a sustainable approach, supporting the system in reaching the state in which emergence of antifragile operation may happen.

Wakogh et al. (2021) provides a clear definition: “the psychological stability, or the psychological illnesses of a person.” Stability is related to balancedness and robustness properties of the system. Defending the boundaries of the model is done by the proper definitions component supporting it.

Gould et al. (1987) offers a sport-specialized definition: the skills of mental toughness, positive attitude, individual motivation, attention-concentration, goal setting and prematch mental preparation. The factor psychological status is capable of enhardening the human factor, reducing the permeability of the system and, therefore, lessening the external variance.

Boucher et al. (2021) defines psychological status as the following: “the status of motivation, positive or negative thinking patterns, passion, mood of a person.” Positive and negative thinking patterns are present in any human factor’s operation, presenting variance. The system is likely to face positive and negative feedbacks as well; to be balanced, the human factor is to smoothen or enlarge the impact as the aim of the model is to present the robustness characteristic.

Stojanov et al. (2020) offers a simple definition: the status of life quality, sleep quality, anxiety and depression of a person. The life quality of the human factor is to be distinguished from the model, as a long negative period is likely to do harm. Once again, the model is to face stimuli by the human factor and resist to change.

The author’s own definition for psychological status of coach and players: a status is categorized as coach’s/players’ psychological status if it shows the harmony of the coach’s/players’ cognitive, and emotional patterns.

4.2.5 FIFTH FACTOR: KNOWING THE DYNAMICS OF THE TEAM

Shipherd et al. (2018) defined knowing the dynamics of the team as knowing “the cohesion, the communication, the coach-athlete relationships and athlete leadership in the team.” The cohesion of the team strengthens its boundaries, through enlarging differences of inside and

outside elements. It is an inner source of boundary creation. The system strengthens by this factor creating strong boundaries, as it hinders the entrance of external knowledge.

Woezik, Benson and Bruner (2020) offers the following definition: knowing the "team structure, emergent group states and group processes of the team." Group processes may hinder, but also foster the evolvement of the system, as these processes are not necessarily inner processes only. Processes that are connected to the environment of the system inevitably cause outer information to enter the system, therefore, the human factor is to smoothen this outside information.

Lin and Shih (2018) defines knowing the dynamics of the team as knowledge about "the team's group development process; activity execution; leadership; group cooperation; personalities; behaviours; interactions and inter-relationships with group members." The group development process is responsible for making the team more central in the operation of the system, meanwhile it decreases the system's need for outer stimuli.

Dougas (2017) identifies it as knowledge of "the involved people's positive and negative roles in the team when achieving shared goals with interdependence." Interdependence in the system is likely to increase with time, although this increasement might make it more fragile. As the aim of the model is to provide robustness in the system, a harmony of interdependence is to be mediated by the human factor.

Rosmalen and Oldehinkel (2011) defines this element as: "knowledge of the team's design: structure of the task, the composition of the team and norms about the performance process." The structure of the task requires the system to transform to the shape that might yield the highest performance in getting the task done. Such an elasticity is presentable by the model as well, as elasticity does not require the lack of robustness.

Filho, Tenenbaum and Yang (2015) defines this factor as: "knowledge of member attributes, team environment, team structure, team cohesion and team processes." The team structure is modifiable by the coach, and the environment as well, although the more inside focused the team is, the stronger boundaries it has and the less impact the coach and the environment has on it. On the system level, the changes of team structure are capable of supplying inner stimuli for the evolution of the system.

The author's definition is the following: a knowledge is categorized as knowing the dynamics of the team if it contains the key pieces of information about the team.

4.2.6 SIXTH FACTOR: PLAYER'S TECHNICAL KNOWLEDGE

Rechenchosky et al. (2017) defines player's technical knowledge as the knowledge of "motions that a player needs a considerable time to master." Technical knowledge in the system shares the characteristics of coach's theoretical and practical knowledge, as it is easy to verbalize, though only acquirable through action. This factor in the system has clear boundaries, and has the needed openness for knowledge exchange, helping the system to evolve towards antifragility.

Carson and Collins (2016) forms a definition as following: "knowledge of skills that contribute to the performance of the athlete." Though the definition is general, in the team the author considers them to be part of abilities. The system is to reach antifragile operation through emergence.

Koopmann et al. (2020) suggests the definition as a "knowledge that is dynamic and individual during development, and unique to the sport and its role- and position specific demands." Despite the fact that human factor in any system presents a different mixture of abilities, building the system is done by the human factor knowing what its own, and the system's characteristics are. The uniqueness of the system is ensured by this factor, which is strongly related to feedbacks – and in a larger sense, stimuli – that the system receives.

Hatze (1973) offers a plain definition: "knowledge of motions yielding performance under given conditions for a given individual." Systems are not always in the situation in which they can influence their environment and the conditions they face when operating. It depends on the type of interactions and the openness of the system and the environment. The boundaries of the system are well strengthened by previous factors; this factor emphasizes the interdependence between the system and its environment.

Glazier and Mehdizadeh (2019) defines as "knowledge of movement patterns aiming to be the closest to personal to-be achieved ideal technique." The evolution process of the system rests on the balance between robustness and openness; the human factor is the one which should find this balance. In sport setting where results are key measures of performance, the ideal operation of the system might be known, and pursued.

Puhalj and Lesnik (2018) defines this knowledge as: "knowledge of movement patterns which are related to well-functional execution determining the quality of movement." The movement of any element (knowledge, abilities or any kind of information) determines the operation of the system.

The author's own definition for this factor is the following: a knowledge is categorized as player's technical knowledge if it contains movement patterns that enable the athlete to efficiently achieve a set goal in sport setting.

4.2.7 SEVENTH FACTOR: PLAYERS' TACTICAL KNOWLEDGE

Zadorozhna et al. (2021) defines tactical knowledge as "a set of ideas about the means, types and forms of sport tactics." Tactics are a structured motion of elements of the team.

Reference [39] suggests tactical knowledge is "a knowledge that refers to the athlete's ability to declare (verbally and/or in writing) "what to do", decisions to be made and to justify them." Tactical knowledge refers to the team's ability to respond to a situation which was caused by inner or outer actions. For the ideal evolvement process, it is the human factor to prepare the system for the emerging situations.

Menegassi et al. (2018) refers to tactical knowledge as "the athlete knowing "what to do" in a certain situation." The athlete's preparedness for situations determines the quality of the response; this quality has an effect on the evolvement of the system.

Cardoso et al. (2019) offers the following definition: "the knowledge of what to do in situations that is developed gradually throughout the training process." As the knowledge of the players are increased with proper training, building the system between the coach and the team takes time and effort as well to support the evolution.

Serra-Olivares and Garcia-Lopez (2016) identifies the player's tactical knowledge as knowing what and how to do, and also knowing "why to do" in a certain situation. It is built up from two categories: declarative knowledge and procedural knowledge. "Why to do" emerges in the system's operation as well, and it is strongly related to the operation of the participants of the model.

Amaral et al. (2018) defines it as "a knowledge the athlete possesses of the game, of the logic of the game." Logic is a characteristic that the human factor owns, and is at least partly embedded in the model's factors.

The author's own definition for player's tactical knowledge: a knowledge is categorized as player's tactical knowledge if it contains complex knowledge of the game, which as a game-sense helps what, how and why the player acts in different game situations.

4.2.8 TENTH FACTOR: POWER STATUS OF PLAYERS

Sanders and van Earp (2021) defines power status as "the maximum mean power output athletes can produce over different situations." The amount of power the system, and the environment can exert determines the variance the system faces.

Kim et al. (2020) defines power as: "power is the asymmetric control over various resources in social relationships." The coach and the team are to control resources that are either inner or outer types, are determining the size of effect the system is able to make on the environment and vice versa.

Fallon (1999) offers the following definition: power status is defined as "the level of autonomy which increases as the person becomes more educated." The autonomy of the system is to be reached by the evolution it goes through. Antifragile operation requires a firm amount of autonomy, in a well-balanced manner.

Kemper (2006) defines power status as the following: "the possibility for players to realize their own will, even over the resistance of others." The model is to be presented mostly by the human factor, although it is constructed to be robust. The human factor is to overcome this resistance if a change is required.

Goldhamer and Shils (1939) suggests: "the sum of player's abilities to influence the behaviours of others in accordance with their own intentions. Three types of power are distinguished: force, domination and manipulation." The intention to have an effect on the environment is well seen in any system's operation which are not closed: open systems are to cooperate with the environment for the sake of the evolution.

Harsányi (2000) approaches from a biological method: power is "an ability which is produced by muscle contraction, in order to overtake relatively big resistances. It directly defines performance." The amount of resistance is a key element of the system's operation, either towards inner, or outer influential forces, as it results in the movement of elements in the system.

The author's own definition is the following: a status is categorized as power status of the players if it shows the ability to overcome resistances, either in physical or mental manners.

4.3 DISCUSSION

In modeling any system that contains robust and antifragile components, the balance is to be found to ensure the highest possible evolution process the system is capable of. In the case of an ice-hockey team, this evolvement results in high performance. As the model is backed up

with a definitions component with clear boundaries, the human factor of the system has an easier task to provide the right number of stimuli the system must face to evolve towards antifragile operation. If an ice-hockey team improves in the factors mentioned in the paper, its performance increases, while the author's model serves as a base of understanding the improvement. Although to keep their orbits, balanced development may be required from the coach, and the team as well. The aim of the system is to be in a state in which it is robust, and evolvable (Kim et al., 2020).

The human factor in the system is to equip the system with a characteristic that it responds robustly while evolving to stress. In the case of an ice-hockey team, many outer stimuli (the fans, the ice-rinks, their families and friends) reach its boundaries. The team cohesion is strongly connected to the openness of the team, therefore, a balance between cohesion and openness is to be found by the team as a whole to support antifragile operation.

4.4 LIMITATION

The definitions from references are sport-specific in every case, meaning the author applied the information to sport setting. It is not known by the author, whether more suitable definitions are already present in the scientific knowledge base.

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5. CHAPTER: COMPLEX ICE HOCKEY TEAM PERFORMANCE MODEL BASED ON EXPERT INTERVIEWS

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ABSTRACT

Scientific research focusing on ice hockey is growing, although a complex model describing team performance is yet to be added to the knowledge base. The purpose of the study is to finalize the authors' proposed model of ice hockey team performance and gain insights on how the included factors contribute to the operation of the team and the coach. Based on the processed literature, it was assumed that the psychological aspect is among the key factors contributing to team performance. Semi-structured interviews were conducted with highly qualified experts on Hungarian ice hockey (five national team coaches and five senior national team players). The results indicate that the psychological factors of the coach and the team are essential for high team performance, along with the influence ability of both sides, creating two-way communication and feedback loops. The practical knowledge of the coach was emphasized over theoretical knowledge, and the team's tactical knowledge was emphasized over technical knowledge. It also emerged that the coach must know the team well in order to make appropriate decisions. The role of the coach is no longer to act as a stressor, but rather to set a good example as a role model while remaining open to feedback from the team's side. It was concluded that although many psychological methods are available to improve performance, the use of these methods has not yet been sufficiently exploited. While the use of these methods could improve performance, the team could experience more success and make sporting activity a fundamental part of players' health through bonding and belonging.

Keywords: ice hockey, role change of coach, sports psychology, team performance

5.1 INTRODUCTION

Ice hockey is said to be one of the most complex games among all sports (Schulze et al., 2021), as the whole body of the player is used in order to achieve a set goal, either in scoring a goal or winning a championship. As the competition level of the game increases along with new knowledge that enters the field from outer sources, players must be equipped with knowledge and abilities that allow them to compete for success (Davletmuratov, 2021). When considering success from the coach's point of view, the measure of success is not always the final result of the game, as coaches are responsible for teaching the game to the athletes, and this process might include periods without success. Professional and recreational ice hockey have different characteristics, as the aims of the activities are different by nature. Although a recreational ice hockey player might want to win as their primary aim, learning and playing on a team that offers a great community for building relationships might become a preference over winning. Professional sports are inherently competitive, and winning is expected from the stakeholders of professional clubs. In order to proceed, it is reasonable to consider both as part of a system, with professional ice hockey on the top as a role model for recreational ice hockey. Teaching sometimes takes the form of focusing on a specific element of the whole (Lemyre, Trudel and Durand-Bush, 2007). By learning that specific element, the player may experience success over the long term. Therefore, ice hockey games have both short- and long-term goals, making them a complex phenomenon and creating the possibility to learn about processes of life (Chard, Edwards and Potwarka, 2015). Although many sports have this common feature, success is an inevitable form of positive feedback that the players and the coach must face in order to maintain intrinsic motivation to participate in the game (Haraczkiewicz, 1979). When executing an action plan that aims to help children develop so they may pursue a professional career, many players experience anxiety, which has diverse effects on their sports performance (Listea et al., 2017). It is best if children begin learning the game around 6 or 7 years of age, as the players can possibly master the game if they invest a significant amount of time in practice (Ericsson, Krampe and Tesch-Römer, 1993). The numerous hours spent training to improve performance have multiple beneficial effects. First, the time spent training protects children from spending time in troublesome situations that could put them in danger. Second, the main idea behind participation in sports is to increase one's wellbeing by satisfying the basic need for movement. Third, coaches with a skilled pedagogical sense can protect children from adverse childhood events that could lead to health-harming behaviors (Bellis et al., 2014).

Participating on a team in which realistic feedback loops are present could balance out the effects of bad parenting, which could lead to the development of perfectionism (Damian et al., 2013). In the case of an effective action plan for helping children develop into professional athletes, learning to work hard is part of the process. Hard work is said to overcome talent if the talent does not work hard (Larsen et al., 2013). However, being talented and investing energy in improvement is a crucial combination for long-term development. This applies to the coach as well, although the coach's knowledge of the game can be acquired through an athletic career before coaching, and such a background increases their chance of being accepted as an authentic person leading the team (Pitts and Evans, 2020). The leadership function of the coach is strengthened by naming them the formal leader of the team, although team captains also help teams function, along with the informal, situational leadership functions that arise when leadership is necessary to achieve a goal. Everything the players learn comes from a hybrid source: the players learn from the coach by doing and watching (Keays and Pless, 2013). This hybrid solution is best if the player has intrinsic motivation, as the coach can help guide them and make sure they retain long-term knowledge of what they have learned, even when they learn by watching. This solution is similar to situated learning, as highly educated teams share some of the properties of a well-established community of practice (Kirk and Kinchin, 2003). Although competition has downsides if the goal of the players does not match the team's goal, highly competitive players are very useful assets in the hands of a coach as these players show high intrinsic motivation towards the game. It is up to the coach to set goals for these players to maximize their use when working towards the team's goal (Bennie and O'Connor, 2010). As these highly competitive players find doing sports a great activity for development, they show a strong orientation towards sports (Gill, Dzewaltowski and Deeter, 1988). Personality characteristics can possibly differ regarding the age, gender, and position of the player (Kőnig-Görögh et al., 2017). The development of a player never stops, even when they are playing in a professional league. In a similar vein, the greatest coaches never stop learning about their sports, either (Olusoga et al., 2011). The need for power – in this case, defined as the control over resources – is present in the behaviors of competitive players. Although hierarchy is a natural phenomenon when teams, especially sports teams, work together (Waldron, 2015), the roles in this system are dynamic and ever-changing, meaning players have the chance to restructure the team in an endogenous process. The role of the coach in this process depends on the coach's personality and their method for achieving success (Lanning, 1979). Coping with

success is a phenomenon in which players learn how to handle situations when they face the pressure to succeed (Kuleva and Iancheva, 2017). In addition, the perceived motivational climate may have a contributing effect on the level of motivation (Szemes, Szájer and Tóth, 2017). The psychological status of the coach and the players is assumed to be the most important factor contributing to excellent performance (Swann et al., 2017). Working on intra-team relationships with psychological support is a proposed method for increasing team performance (Brynzak et al., 2021). Excellent performance may take the form of winning more competitions on the ice than the opposing team (Parnican, Tóth and Peracek, 2020), but it is characterized by the creation of many chances to score, which results in winning (Sgro, Barresi and Lipoma, 2015). Psychologically strong players are capable of making use of powerplay situations that often lead to scoring goals (Barilla et al., 2019). The current research represents a research stage in which the proposed model is finalized with the help of highly qualified experts from the Hungarian ice hockey sector (see Fig. 1).

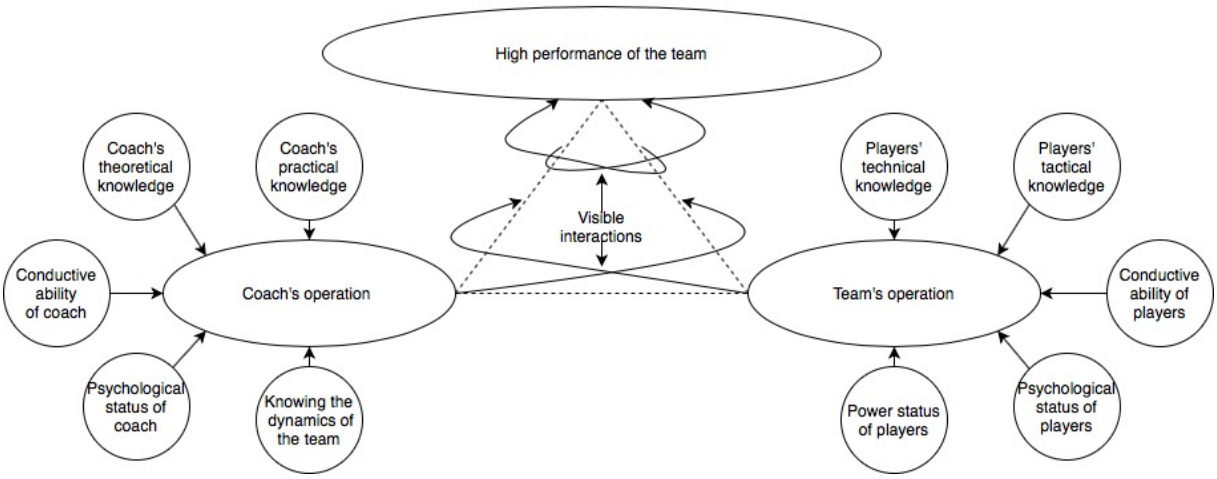

Figure 1. *The authors' proposed model of ice-hockey team performance. Source: Géczi (2021a).*

The complexity of the model lies in its inherent feature of non-linearity and the dynamic emergence of the mix of factors that are reciprocal with the environment. For example, in a game against an opponent, the opposing team is an environmental factor and has an effect on how factors contribute to high performance. The high number of factors enables synergies to develop between factors, resulting in emergent phenomena. Although a mix of factors is present, the interaction and orbit dynamics (the middle part of the model) are to be explained

as follows: the coach and the players have characteristics that they are both responsible for developing. The interactions are a result of the development orbits crossing each other, in which information exchange is present. As in professional sports, the aims of the coach and the players are similar (mainly involving the goal of winning the game through high performance), the orbits are moving towards a shared goal, and if group dynamics processes are present, the distance between orbits decreases over time. In this process, the interactions are inherently characterized by having an attracting effect afterwards, which brings the parties towards the shared direction. This attractive force relies on cooperation and cross co-adaptation towards the characteristics of the parties.

5.2 METHODS

As the aim of the research is to finalize the model that describes the factors of high performance for ice hockey teams, the proposed model was tested with the help of highly qualified experts on Hungarian ice hockey. It is assumed that professional-level coaches and players are capable of providing insights for practitioners and players of any level of sports activity. In order to meet these quality standards, five Hungarian national team coaches and five Hungarian male senior national team players were interviewed through semi-structured interviews (Whiting, 2008). The mean age of the coaches was 48.4, with a standard deviation of 7.37, while the mean age of the players was 31.2, with a standard deviation of 3.63. The interview questions were published in a previous study (Géczi, 2021a). As the interviews were semi-structured, all the factors and interactions were covered by the questions, enabling the interviewees to provide feedback on each part of the model and highlight their relationships. In the case of choosing the national team players to be interviewees, diversity was the main goal. Therefore, a goalie, two defensemen, and two forwards were interviewed; two of them were team captains in their club teams. Seven of the ten interviews were held in person, while three of them were conducted online. The proposed model was shown and explained to the interviewees before the questions were presented. The interviewees were numbered from 1–10: 1–5 for coaches, 6–10 for players. The in-person interviews were recorded with an audio recorder, while the online interviews were recorded with the built-in record function of the software that was used. All of the interviewees gave their permission for the interviews to be recorded and used for the current research.

5.3 RESULTS

The factor of the coach's practical knowledge turned out to be an important factor in team performance, as was highlighted by many of the interviewees. For example, one interviewee stated the following: "It includes the experience of the coach, how many years he spent working as a coach, and who he could learn from" (Int1). The interviewed players clarified that work experience as a coach is a crucial factor, as less experienced coaches are unable to properly understand complex situations that arise. Some of them identified the tactical knowledge of the coach as being included in this factor, along with the ability to transfer this knowledge to players. Int7 clearly identified this as the most important factor: "I think this factor is 90% from the coach's side, the remaining 10% is what the coach brings from other areas of his/her life." This factor also includes the coach knowing what to expect from the opponent. According to Int10, "As the competition level increases, the coach's practical knowledge level must improve as well." Therefore, the factor is included in the final model. Regarding the factor of the coach's theoretical knowledge, the interviewees made clear that although theoretical knowledge is important, putting it into practice is essential. This was emphasized by statements such as, "I think theoretical knowledge gains significance if the theoretical knowledge can be seen in practice" (Int3). It also turned out that the higher the team's level, the more important theoretical knowledge becomes. Therefore, it is included in the final model. The third factor, the conductive ability of the coach, is related to communication and feedback mechanisms in the team. For example, according to Int1, "From my own experience, it was always important for me to get feedback. If no one talks to you for months, you don't know whether what you do is good or not." The coach must be a strong motivating force, although it is important that the coach find a common language with the team: "The players and the coach must also want to win; then it is easy to influence the players. If a player decides that he does not care about the coach, the coach can't influence him." Transferring or controlling players' feelings is a top priority for coaches, as it significantly affects team performance. According to Int4, "Nowadays is not like the old days, in which the coach yelled at the players. The modern coach is a teacher as well." Respect and authenticity also turned out to be important in relation to this factor. If a coach cannot transfer their knowledge, the team is not going to work. Int8 clearly pointed out that "If you are convincing as a coach, there is going to be performance." This factor is said to unlock doors and enable the coach to build trust with the players. This factor is included in the final model with a small modification in the name: the conductive ability of the coach is

modified to the conductive influence ability of the coach. The factor of the coach's psychological status has serious effects on team performance as, according to the interviewed players, the psychological status of the coach is transferred to the players. Although Int6 pointed out that "The coach's status does not matter if he/she can still manage and motivate players," most of the interviewees clarified that the coach sets an example for the players. For example, in a high-pressure situation, the coach can act as a role model. The factor of knowing the dynamics of the team is seen as an important factor as well. Int6 expressed the following: "I think this is very, very important. If this is clear for you as a coach and you know who to use for specific tasks, it is important to be successful." There are different types of coaches; some of them keep a certain distance from the players, while others are more player-oriented and try to learn as much about the players as possible. Although Int7 pointed out that "I think in the modern world, the distance between the coach and players is fading away," there is information about players that is said to be "personal business" (Int10), while other types of information must be shared with the coach so they can make appropriate decisions. The leading players of the team, therefore, are used to filter the information and present the important pieces of information to the coach. Regarding the coach's operation, an important process emerged: the coach must be able to read the coached team. This phenomenon is present in conductive ability, as influencing the players requires the coach to know what path can be used to influence the players. In addition, knowing the dynamics of the team enables the coach to know the players. Theoretical and practical knowledge also involves reading the team as an important process when transferring knowledge to them. Int9 stated that "The factors are well taken. If you stick to those five, you are going to be a good coach. The factors serve as a great foundation." In order to build the phenomenon into the model, the factor of knowing the dynamics of the team was replaced with knowing the team. With this modification, the coach's operation was finalized. The next factor is the players' technical knowledge. Int1 clarified that "It is good, if you have a lot of highly skilled players because you can send a strong team onto the ice, although technical knowledge is not everything. Less skilled players can make up with working harder." Technical knowledge is also related to tactical knowledge when the team plays. In an optimal case, the tactics are well suited to the technical knowledge of the players. Technical improvement is said to be important for players at the highest levels as well because it could offer a competitive edge among the players. Int7 stated that "A team can still be successful if players are not that skilled, although good, fitting tactics are played." The factor of players'

tactical knowledge was marked as highly important in the interviews and seems to be the key for high performance. According to Int2, "Tactical and technical knowledge are related. If a coach teaches a certain tactic, and four players know where to go, but the fifth does not go in his place, he messes up everything." What emerged from the interviews is that not only tactical knowledge, but also tactical discipline contributes to high performance. Int4 said, "I would use zero tolerance in this factor. A player not knowing the tactics but being highly skilled will not build himself in the team, and performance will not happen in the end." The role of the coach in this process is to make clear how the player should act in adverse situations. Ice hockey is said to be a read-and-react game in which tactical knowledge is crucial. The factor of the conductive influence ability of the players was cut short by Int2: "You are convincing, if you win. Many of the players try to convince the coach that he is a good player, but in reality, he is not. It's more important that you put 100% on the ice." The teams have team captains and leading players who are mostly highly experienced older players. It is important that these players have some influence on the coach; otherwise, the coach will not be capable of knowing the team on a sufficient level. Int7 said that "In the old days, one-way communication between the coach and players worked, but in modern times, two-way communication is needed to step forward." This factor is also included in the final model with a modification from the conductive ability of players to the conductive influence ability of players. Regarding the factor of the psychological status of players, Int4 clarifies that "Every player must be in a good psychological status to avoid rampages and penalties." During a long tournament, it is often the case that players first become mentally exhausted long before physical exhaustion sets in. Int8 adds that "If the psychological status is good, there is performance." This factor is related to conductive influence ability as well because if the coach can convince the team that there is a chance to win, it becomes the most important reason the players will perform well. The importance of the factor of the power status of players is seen as an important one that must have a condition for the players. According to Int3, "If a player is not in an appropriate condition, the team performance will decrease over the long term. In the first 10 games, you are okay, but on the 40th game, you are not usable." A certain condition status is expected from a player when they are trying to play in a professional league; otherwise, the player cannot get a contract from the team. The hierarchy in the team also has an effect on team performance. Int10 made this clear by saying, "I think the stronger the hierarchy in the team, the more damaging it could become. I believe that the sense of unity, purpose and that each individual player has a value he/she can

bring to the team. If players start to feel that a fourth line player is less important than a first line player, the team is going to underachieve." Making the players feel valued is part of the coach's job when working with teams. Three out of ten interviewees suggested that team unity should be included as a sixth factor in the model, although Int8 said, "Yes, the five factors cover the whole operation of a team, but the factors could be spoken of in detail all day long." Team unity is a factor that is contained in the psychological status of the players, as the optimal mentality includes thinking in a team context, not according to individualistic behaviors. To build this phenomenon into the model, the five factors of the team's operation were all modified from that of the players to that of the team. In addition, the tactical discipline part was built into the tactical knowledge factor. With these modifications, the team's operation part of the model was finalized. For the question of whether the coach and the teams should have visible and non-visible interactions, the answers were homogenous. Int3 highlighted this by saying, "Absolutely, both types are needed. In a case when team cohesion is needed, the non-visible interactions are needed the most." When answering the next interview question, the interviewees confirmed that when the orbits of the two participants of the model are moving towards each other and interactions happen, it supports high performance. Int10 said that "Obviously, there has to be cooperation, yes. When there is a lot of cooperation, the key elements – honesty, reinforcement, positive energy, positive environment – create more opportunity for learning." For the next question of whether the system is balanced and both participants keeping their orbits supports high performance, the answers were once again homogenous. Int1 confirmed, "Absolutely, this is an ideal case, but it happens rarely." Int10 added valuable information: "Having the balance is really important, because it is a high-speed game that depends on decision-making in a split second, and in terms of team chemistry, players that are too dominant can really divide the team. Coaches that are too dominant paralyze the team." The next question in the interviews was whether the model describes the operation of a high-performing team. Int2 confirmed, "Yes, the model describes a team that is capable of reaching high performance in an optimal case." Int4 went further: "Yes. The model is ideal, and it would be great if all teams would work like this." Therefore, the middle part of the model was also finalized (see Fig. 2).

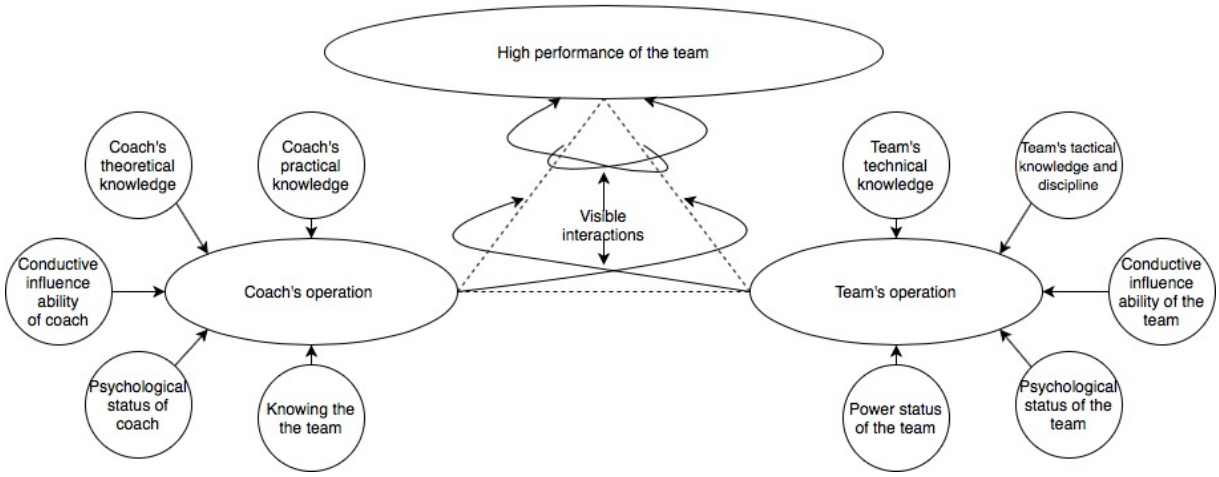

Figure 2. *The authors' finalized model of ice-hockey team performance. Source: own creation.*

5.4 DISCUSSION

Many factors could contribute to the success of an ice hockey team, and success correlates with high performance in ice hockey. The finalized model contains the ten most important factors that have the highest possible effect on ice hockey team performance, although all teams work differently, as each coach and player has a different personality and a unique way of performing well (de Haan et al., 2013). Based on the interviews, it is clear that the psychological side of performance dramatically increases in significance when a coach wants to improve the team's performance. This finding is analogous with previous studies (Newland et al., 2013; Swann et al., 2017). In high-level ice hockey leagues, enlisting the help of sports psychologists is a frequently used method for keeping players and even coaches balanced and in condition to perform their best (Brewer et al., 1998). In addition, the old-fashioned style of coaching, in which coaches yelled at players to perform well, is exceeded by the modern and friendly method of coaching mentioned by the interviewees. This method includes having an open-door policy (Lenskyj, 1994), two-way communication, and feedback loops (Nash, Sproule and Horton, 2016). The coach must know the players deeply in order to recognize and make use of players' moods (Zanini et al., 2018). Strong unity is required by the team and can be maintained by the players when they are guided by the coach and the leading players (Nacar and Gacar, 2013). In order to make all players feel they are valued and are a useful part of the team, the coach must pay attention to properly communicate the roles of certain players on the team and provide feedback based strictly on their roles. The coach, as a strategist, must be up-to-date with the

latest knowledge on theoretical and practical matters. In addition, the coach must improve their communication abilities to act as an authentic role model for the players (Lau, Chung and Hwa, 2020). Ice hockey is said to be "very beautiful from the outside, but very complex from the inside" (Int4). The finalized model is capable of providing a thorough framework for practitioners who want to understand the performance issues of their teams or further improve the overall performance of their teams. The major limitation of the study is the fact that only professional-level practitioners were included in the research, and no experiment was done to confirm the model's validity for practical contexts, meaning it is assumed that theory drives the action of practitioners in real-life situations. It is also assumed that professional sports represent a goal for different levels of ice hockey activities to move towards. The assumption that the operation of professional-level ice hockey teams should be adopted by recreational-level teams should also be researched in the future.

5.5 CONCLUSIONS

The psychological aspect of team performance is gaining significance in modern sports, and the role of the coach is evolving into that of a role model who sets an example for athletes. We have observed and acknowledged that many psychological tools – such as team building with the help of sports psychologists and psychological self-development – are all accessible, and the use of these is emerging from the cooperation of athletes and coaches. The common interest of the parties is to cooperate in such a way that enables the sport to function as a source of wellbeing and offer competition as a method for development. It is recommended that coaches equip themselves with psychological knowledge to promote athletes' wellbeing, even in professional ice hockey. From the players' side, it is recommended to create a team culture with the help of the coach in which positive feedback is dominant and competitiveness is balanced even in the leagues of the highest level. Experiencing success in sports contributes significantly to the development of emotional bonds, and feeling unified within the team offers a great experience for both athletes and coaches. These experiences establish sports as a lifelong activity, make athletes love their sport, and help sports become a fundamental part of the image of health. Thus, bonding and belonging support the health of athletes for a lifetime.

6. CHAPTER: STATISTICAL ANALYSIS OF ANTIFRAGILITY IN HUNGARIAN ICE HOCKEY GAMES

Reference: Géczi, G. and Baracskai, Z. (2022) 'Statistical Analysis of Antifragility in Hungarian Ice Hockey Games', *Hungarian Statistical Review,* 5(1), pp. 75-93.

ABSTRACT

Professional ice hockey provides a great environment for studying the antifragile behaviour of teams because of publicly available results and statistics. This study examines three-goal events in which a team gave up a goal but responded by scoring two goals. Thirty-four ice hockey games are studied from the last ten seasons of the Hungarian first league to identify the events' characteristics and to determine whether antifragile behaviour emerged in these events. The results indicate that if the opponent scores first and has a one- or two-goal lead, the team that responds with two goals after strengthening the line exhibits a convex and, therefore, an antifragile behaviour. Antifragility has been found in 22 cases, lending support to the assumption that antifragile behaviour emerges from high-level cooperation.

KEYWORDS: antifragility, convexity, nonparametric tests

6.1 INTRODUCTION

Ice hockey teams are great examples of complex systems (Davids et al., 2013) that might produce unexpected behaviours when different elements (in the case of an ice-hockey team, team members) interact with each other and teams interact with each other in games. The teams' characteristics are measured with a broad range of statistics in professional sports (Mosteller, 1997), although the teams' behaviours are measured through certain game situations, such as power play usage (opposing team has a player in the penalty box and fewer players on ice) and penalty killing (the team has a player in the penalty box and fewer players on ice). However, the ability to immediately respond with two goals to one goal against can turn games in favour of the team in focus.

A team's antifragile behaviour (Taleb, 2012a) in an ice hockey game is defined in this study as the immediate response with two goals to one goal against during equal-player situations. As every professional coach aims to win as many games as possible in their quest for championships, a team's antifragile behaviour as an emergent characteristic could give the team a competitive edge over opponents (Kennon, Schutte and Lutters, 2015). Data on antifragile behaviour can be obtained through practices and games, although games are the only source for public information. Accordingly, this study uses data from Hungary's first ice hockey league (currently known as Erste League).

We aim to identify the characteristics of three-goal events in professional ice hockey games and whether these events show antifragile behaviours. The study begins with an overview of antifragility in ice hockey games and a short review of statistical analysis in sports. The statistical methods used in this study are descriptive statistics, parametric or nonparametric tests depending on the sample variables' normality, correlation, and cluster analysis.

Understanding these events can help academics and practitioners build antifragile teams, an issue of interest to all participants in professional sports.

6.2 LITERATURE REVIEW

Planning and executing process as per the plan can help achieve certain team behaviours, although spontaneous processes might also produce the desired behaviours (Yu et al., 2018). A one-fits-all approach does not exist, as each team has different participants and structures. However, successful teams share common characteristics, especially regarding self-management (Levi and Slem, 1995). Self-management is an endogenous activity that can occur either as a planned or spontaneous process (Bertolotti, Macrì and Tagliaventi, 2005). Spontaneous conversations contain a higher number of turns than planned ones do (Taboada, 2006). By contrast, planned conversations offer more development through more diverse interactions (Linley and Joseph, 2004). The team's performance is also related to diversity, as more diverse teams perform better (Parshakov, Coates and Zavertiaeva, 2018).

As sports leagues aim to maximise competition in games (Rosner and Shropshire, 2004), they group teams that play at similar levels, which constrains the teams' development. However, facing as many teams as possible to have diverse interactions has geographical, fiscal, or physiological limits. Moreover, playing teams that are at the same level can make a team robust in progressing toward antifragility (Johnson and Gheorghe, 2013). In the development process,

cooperation might increase the chances of a system's (team's) survival and success (Leitao, Valckenaers and Adam, 2009), although it is not considered vital in the evolution of networks (Perc, 2009). Cooperation acts as a starting point for a system to evolve, as shown in Figure 1.

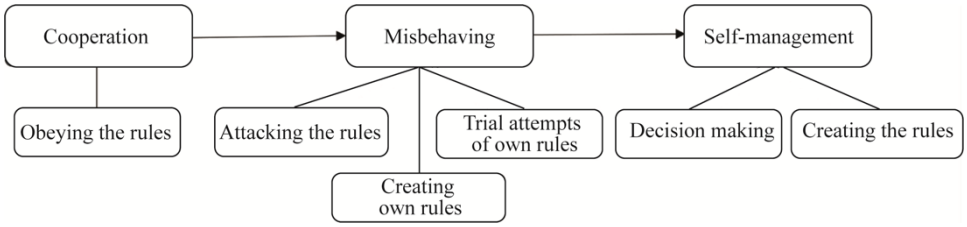

Figure 1. *The evolution of a self-managing team. Source: own creation.*

Learning is inevitable in the evolution process, where the components of a system eventually become systems with their own components. Cooperation serves as a strong factor in sports teams' cohesion (Garcia-Mas et al., 2009). Sports teams are internally cooperative, but are externally competitive, with many stressors affecting the performance of athletes (Mellalieu et al., 2009). Eustress and distress have separate effects on athletes' performance (Brandao et al., 2021), although whether both should just be called 'stress' and considered phenomena triggering adaptation mechanisms, remains an open question (Bienertova et al., 2020). Stressors can improve people's arousal level (Noteboom, Barnholt and Enoka, 2001), and achieving the optimal level of arousal is key for performance (Kerr, 2007). Managing the team's arousal level is a learned method based on the evolution model. Initially, the athlete cooperates with the coach to learn the rules. Afterwards, the athlete misbehaves and creates own rules for self-management. Lastly, this method becomes part of self-management, which is performed without external impact. Antifragility is important when dealing with complex systems (Russo and Ciancarini, 2017). Collaboration is a key strategy to achieve common goals with antifragilistic attributes: convexity through decreased probability of failure and increased probability of success (Ramezani, Camarinha and Matos, 2020). In addition, cooperation is identified as a facet of collaboration (Gulati, Wohlgezogen and Zhelyazkov, 2012). Therefore, a higher cooperation level leads to more antifragile attributes in a system.

The use of sports analytics, including sports statistics, is growing (Mumcu, 2016) due to the increased competition in professional sports and wider media coverage. Historically, baseball was the first sport to use formal analytics, starting with 'Percentage Baseball' (Hooke, Cook

and Garner, 1967). ‘Moneyball: The art of winning an unfair game’ became the most influential book regarding the use of sport analytics (Lewis, 2004). The National Football League (NFL) eventually adopted sports analytics by utilizing the methods of an analytics-focused website. In the National Basketball Association, sports analytics was introduced in 2006 by Daryl Morey, one of the chairs of the MIT Sloan Sports Analytics Conference series. The National Hockey League (NHL) was a late adopter of sports analytics, as the latter was only introduced in 2014 by Kyle Dubas. Between 1990 and 2009, sports analytics articles in scientific journals rapidly increased (Coleman, 2012), showing a greater focus on this area.

Ice hockey leagues have a long history of statistical data gathering. In most leagues, these statistics are available for anyone interested in gaining insights on how a player or team performs in certain situations; therefore, these data have been used in various research activities (Stein et al., 2017). As technology for collecting statistical data develops, larger and higher-quality datasets have started to become available for research (Thomas et al., 2017) and performance analysis (Farrow et al., 2018). Professional leagues are likely to invest in the latest technologies to increase their success and profits, and these leagues have the most data (Hutchins, 2016). For example, the NHL shares extensive data about teams and players with fans through its website. These data have tremendous value for academics (Dapiton and Canlas, 2020) and sports professionals or analysts (Fried and Mumcu, 2016). Statistical analysis can help teams gain a competitive edge in games (Carling et al., 2008). In addition, statistical methods can possibly measure the competitive balance of sports leagues (Fűrész and Rappai, 2018). Modelling techniques currently have multiple purposes, including game and championship predictions (Marek, Šedivá and Ťoupal, 2014; Duráczky and Bozsonyi, 2020), player rating activity (Thomas et al., 2013), and team performance analysis (Schulte et al., 2017). The increased use of sports statistics has created new ways to connect with fans by offering a storytelling tool that uses statistical data (Hahn, VanDyke and Cummins, 2018). Meaningful statistical analyses often predict whether a team will win or lose a game (Conte et al., 2018) or a team’s level of success in a season (Ibanez et al., 2008). Therefore, statistical analysis is intensively used in professional leagues, and is used in lower-level leagues if the appropriate conditions of data gathering and processing are present. Sports statisticians are becoming more important to coaching staff in professional leagues due to the increasing availability of data (Green et al., 2006).

The games' results are usually used to measure team performance, although analysing certain aspects of the game might help better understand the team's performance. When games between the NHL and the 2018 Winter Olympic Games were compared, results showed that winning teams won 31% more defensive duels and that NHL matches averaged 36% more duels compared to Olympic Games matches due to smaller rink sizes (Parnican, Tóth and Perácek, 2020). Although the ratio of winning or losing defensive duels is important for coaches and video analysis, this information is not yet available in the NHL statistics databases. Ice hockey games are often seen as a set of duels by coaches; hence, power play opportunities are a critical factor in the results of the games. The 2017 U18 Group A World Cup matches show a strong correlation between power play goals and game results, nonetheless no correlation can be found between power play utilisation and final rankings in the tournament (Barilla et al., 2019). Additionally, for a temporary team, players' shared work experience is positively related to individual and team performance, and teams with a less centralised structure outperform highly centralised teams (Dalal, Nolan and Gannon, 2017).

The ice hockey teams' line structure is where coaches maximise the teams' chance of winning by knowing how effective certain players are with each other. In a centralised team's line structure, the most effective players are in the first line, with less effective players in other lines. By contrast, a decentralised team contains lines where high-performing players are well-distributed, meaning line strengths are based on individual performance measures. Self-efficacy and collective efficacy are distinct notions and have different characteristics when teams work together (Myers, Payment and Feltz, 2004). Aggregating self-efficacy is not equal to collective efficacy, as synergies may arise when a group is interacting (Lindsley, Brass and Thomas, 1995). High cooperation can be caused by synergy between team members and physiological arousal (Jackson et al., 2018).

In ice hockey, individual performance is difficult to distinguish from team performance, although individual statistics for an entire season would likely illustrate an individual's performance. Therefore, season-long statistical measures should be used when defining the players' strength in a game. The antifragile behaviour of a team depends on an important exogenous factor: the amount of stress caused by a stressor. A stressor causing very low arousal levels does not trigger a response; by contrast, a stressor causing very high arousal levels causes the team to freeze under pressure. Therefore, an optimal amount of stress should be presented so the team can respond antifragilely (Hill et al., 2020).

6.3 METHODS AND PROCESSES

In the present study, Team A always scores two goals in response to one goal by Team B. The Erste League is focused on, and data were obtained from its official website and other international databases (http://www.eliteprospects.com). From 2011 to 2020, a total of 2,183 games were analysed using the examination criteria. Three-goal events were recorded in the dataset if an opponent's goal was immediately answered by two goals. A three-goal event is only recorded if no other goals are scored five minutes before the first goal and if the opponent does not score for five minutes after the second goal. All were equal-opportunity situations, wherein both teams were playing with equal strength, with 5+1 players. A total of 35 three-goal events were identified in 34 games. Team and individual performance metrics were available in the data sources consulted, although data on collective line strength were not available. Therefore, individual measurements were averaged to obtain the strength of a given line when the three-goal events occurred. To obtain clarity on the strength of the players in the line, players' season statistics were used. Ice hockey offers multiple individual offensive statistics, such as goals, assists, and total points. However, plus-minus statistics are the most useful as they measure the player's overall contribution to the games. Although the statistics of the three-goal events are accessible, their characteristics remain unknown and their antifragileness remains uncertain.

RQ1: What are the characteristics of three-goal events, and do they show antifragile behaviour?

Identifying the characteristics of the three-goal events starts with analysing the occurrence of these events by season, team, and period number, to know whether these events are specific to the examined variable. Individual plus-minus statistics were used to identify on-ice line strengths in the three-goal events. Therefore, six variables were created for this analysis: 1. Team A's average on-ice line strength at the first goal; 2. Team B's average on-ice line strength at the first goal; 3. Team A's average on-ice line strength at the time of the second goal; 4. Team B's average on-ice line strength at the time of the second goal; 5. Team A's average on-ice line strength at the third goal; 6. Team B's average on-ice line strength at the third goal. Line strengths were calculated by averaging the individual end-of-season plus-minus statistics

of the five players on ice when the three-goal events happened[1]. Descriptive statistics will be presented for the six variables. If significant differences are assumed, an analysis of variance (ANOVA) method will be used (Cardinal and Aitken, 2013) with a least significant difference post-hoc test (Ruxton and Beauchamp, 2008) if they are found to be normally distributed. Otherwise, the Friedman test (Friedman, 1937) will be performed. Pearson correlation was also used to measure the coach's line management activity. A high correlation between variables can occur in the following cases: 1. The same line stays on ice for multiple goals; and 2. the team has multiple equally strong lines, with one line on ice. To identify which case occurred, descriptive statistics will be presented regarding the line change percentages at the three-goal events. In addition, a paired samples t-test will be performed to identify whether there are significant differences between the behaviours of the participant teams' coaches (Ross and Wilson, 2017). If the line change percentage variables are not normally distributed, the Wilcoxon signed-rank test will be performed (Woolson, 2007). The K-means cluster method will be used to find the hidden structure in the data, which are three-goal event scenarios. If large clusters are found in the data, the three- goal events are unique and no patterns are present. If one or only few clusters are found, the events share common characteristics and the analysis will reveal these characteristics. Antifragile behaviour is characterised as small doses of stress that prevent the occurrence of a massive stressor that may harm the system (Johnson and Gheorghe, 2013), and adversity is an efficient stressor (Kiefer et al., 2018). The scenarios where a three-goal event might trigger antifragile behaviour are the following: 1. Team A takes the lead with the third goal or 2. Team A's goal, the third goal, results in a draw. Convexity (Taleb, 2012a) is found in Team A when Team B scored a goal. These two cases were handled separately.

[1] 1 For example, the average on-ice line strength of a team at a given goal is: player 1's plus/minus is 30, player 2's plus/minus is 40, player 3's plus/minus is 20, player 4's plus/minus is 10, and player 5's plus/minus is 5, the average strength of the line is (30+40+20+10+5)/5 = 21.

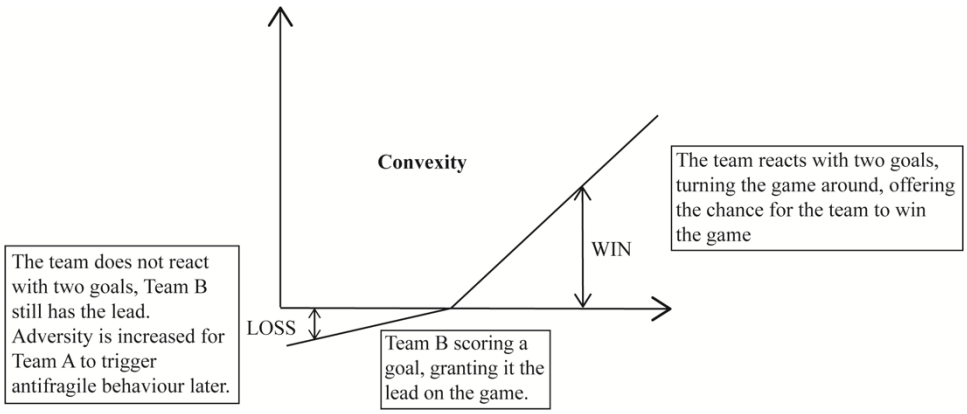

Figure 2. *The convex situation of Team A strengthening the lines on ice after Team B scored a goal to take the lead. Source: Own creation based on Taleb [2012b].*

In this first situation in Figure 2, Team A's strengthening of the lines after Team B scored a goal offers the following possible outcomes: 1. Team A is not able to score two goals and loses the game, resulting in the team getting no points if it is a regular season game or a loss if it is a playoff game. In this outcome, strong plus- minus players could become demotivated since they failed to turn the game around and lost. 2. Team A scores two goals and turns the game around, resulting in the team getting three points if it is a regular season game or a win if it is a playoff game. In this outcome, the payoff of Team A strengthening the line is asymmetric. Team A does not get any points in a regular season game or gets credited with a loss in the playoffs if it does not do anything, while strengthening the lines offers it an opportunity get three points or win a playoff game. This situation is referred to as antifragile behaviour type one.

In the second situation in Figure 3, Team A's strengthening of the lines also offers an asymmetric payoff structure. If the move is unsuccessful, the team loses and gets zero points in the regular season or loses the playoff game. If successful, the team gets one point during the regular season. In the playoffs, this move can only extend the game and offer an opportunity to win the game. This is called antifragile behaviour type two. The data were gathered manually and organised using Microsoft Excel 2019. Statistical analyses were performed using SPSS v24.

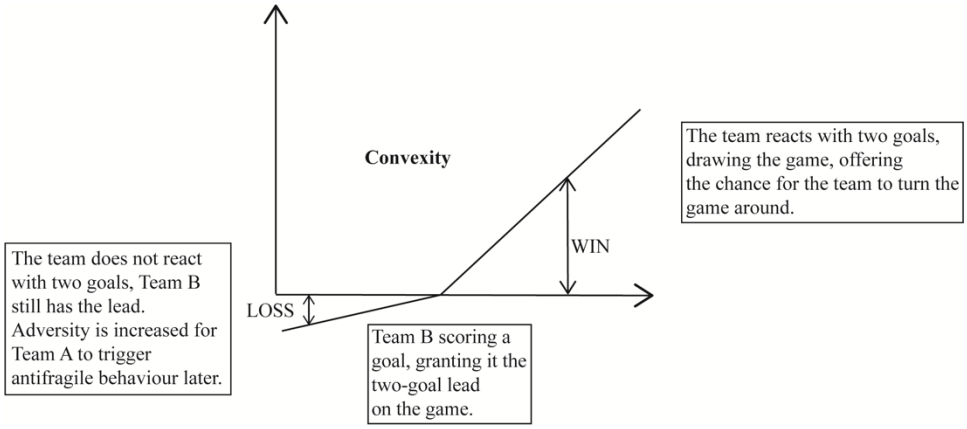

Figure 3. *The convex situation of Team A strengthening the lines on ice after Team B scored a goal that granted it a two-goal lead. Source: Own creation based on Taleb [2012b].*

6.4 RESULTS

6.4.1 OCCURRENCES AND LINE STRENGTHS MEAN RESULTS

The three-goal events were unequally distributed. In the ten seasons that were analysed, 32 of the 35 events happened during the 2015–20 seasons. The increased occurrence in later seasons may be attributable to the improved competition in the league. Three-goal events entice spectators; hence, it is possible that the league became more popular during the study period.

Table 1 shows that the three-goal events were unequally distributed among participants. FTC was involved in seven goal events: twice in 2020–21, once in 2019–20, twice in 2018–19, and twice in 2016–17. Csíkszereda was most often Team B in the events: one event each in seasons 2020–21, 2018–19, 2017–18, 2016–17, 2015–16, and 2013–14. UTE was in the top three in Team A and Team B, and this phenomenon requires further investigation. UTE was Team A in the following seasons: once in 2018–19, twice in 2015–16, and once in 2013–14. Additionally, UTE was Team B once in 2019–20, twice in 2017–18, once in 2016–17, and once in 2014–15. As these data are not concentrated for specific seasons, we have not seen any pattern.

Team	Three-goal events as Team A	Team	Three-goal events as Team B
FTC	7	Csíkszereda	6
DVTK	6	UTE	5
UTE	4	Vasas SC	4
Csíkszereda	4	Brasov	4
Debrecen	3	Debrecen	3
MAC	3	MAC	3
Vasas SC	3	Dunaújváros	3
Dunaújváros	2	FTC	2
Brasov	1	Gyergyó	2
KMH	1	Titánok	1
Titánok	1	Vienna Capitals	1

Table 1. *The occurrence of three-goal events by ice hockey teams. Source: own creation.*

Sixteen three-goal events occurred in the first period of the ice hockey games, 11 in the second period, and 8 in the third period. In every game, ice hockey teams study the opposing teams' styles throughout the periods. The first period is when these behaviours would most likely occur since it is the period for which the biggest possible gap between the teams was found.

Three-goal events occurred in 14 cases wherein Team A was the home team, and in 20 cases where Team A was the away team. Being the away team means less internal and external pressures due to fewer expectations from the management and fewer team fans.

In Table 2, the average line strengths show that Team A had stronger lines on ice for all three goals. This means that the first goal, which was from Team B, was scored by a weaker line. The second and third goals were scored by Team A, which deployed stronger lines than Team B. As a pattern was found in these data, the mean comparison was reasonable.

First goal Team A average strength	First goal Team B average strength	Second goal Team A average strength	Second goal Team B average strength	Third goal Team A average strength	Third goal Team B average strength
7.063	1.480	9.851	–0.977	12.006	–1.251

Table 2. *Averages of six variables of the three-goal events. Source: own creation.*

6.4.2 NORMALITY AND FRIEDMAN TEST RESULTS

The Kolmogorov–Smirnov and Shapiro–Wilk tests revealed that normality was not found in all six variables. Therefore, the Friedman test was used instead of ANOVA. The results showed that chi-square = 21.85, df = 5, and asymptotic significance = 0.001, meaning that the variance of the six variables differs significantly.

The results of Table 3 suggest that Team A has evidently stronger lines for the three-goal events compared to Team B. The highest significant mean rank difference was found for the third goal. Coaches strategically send strong lines on ice shortly after the team scores a goal, resulting in either another goal or higher pressure on the opponent. A mean rank difference was also found in second goals; the pattern is the same as in the case of the first goals. Coaches have offensive and defensive strategies, and matching line strengths with the opponent's line strengths is a good defensive strategy.

Variable	Mean rank
First goal Team A average strength	3.64
First goal Team B average strength	3.23
Second goal Team A average strength	3.93
Second goal Team B average strength	2.74
Third goal Team A average strength	4.50
Third goal Team B average strength	2.96

Table 3. Friedman test results for line strengths as variables. Source: own creation.

6.4.3 CORRELATION AND WILCOXON TEST RESULTS

The results in Table 4 indicate that there is no correlation across the teams. For example, a Team A variable is only correlated with the other two Team A variables. The same applies to Team B, where correlation is observed only among Team B variables. This implies that Team B either had the same line strength or a stronger line on ice when the second goal was scored, while Team A's line strengths were evenly distributed. When the third goal was scored, Team A's line on ice had a similar strength to the line involved during the first goal. If we consider homogeneity in the individual plus-minus statistics of teams, Team A was more likely to change line strength than Team B after the first goal, either by changing another line on the ice or restructuring the makeup of their lines. Team B showed a similar line strength during the first and second goals, while having a differing line at the third goal. By contrast, Team A had different lines when the first and second goals were scored, and the line strength at the third goal was similar to the line at the first goal. Based on the results, Team A's lines were likely to have the same strength at the first and third goals, while Team B's lines were likely to have the same strength at the first and second goals.

Variable 1	Variable 2	Pearson correlation strength	Significance
First goal Team A average strength	Second goal Team A average strength	0.793	0.000
First goal Team A average strength	Third goal Team A average strength	0.877	0.000
First goal Team B average strength	Second goal Team B average strength	0.852	0.000
First goal Team B average strength	Third goal Team B average strength	0.888	0.000
Second goal Team A average strength	Third goal Team A average strength	0.837	0.000

Second goal Team B average strength	Third goal Team B average strength	0.761	0.000

Table 4. Correlation between the six variables of three-goal events. Source: own creation.

Table 5 shows the teams' different lines for the three goals. The means of the line change percentages vary. Kolmogorov–Smirnov and Shapiro–Wilk tests were also performed for these variables, which further proved that they did not show normality. Therefore, Wilcoxon signed-rank tests were used to identify the differences in coach behaviours captured in line change percentages.

Variable	Mean (%)	Standard deviation (%)
Team A line change % 1st–2nd goal	81.71	27.59
Team B line change % 1st–2nd goal	72.57	33.98
Team A line change % 2nd–3rd goal	74.29	33.10
Team B line change % 2nd–3rd goal	82.86	27.93
Team A line change % 1st–3rd goal	62.29	30.20
Team B line change % 1st–3rd goal	68.00	36.36

Table 5. *Descriptive statistics of line change percentages in the three-goal events. Source: own creation.*

As seen in Table 6, no significant differences can be found between the participant teams' line change behaviours, meaning equality may be assumed in the coach behaviours between Teams A and B.

Variable pairs	N	Test statistic	Standard error	Standardized test statistic	Asymptotic significance
Team A line change % 1st–2nd goal – Team B line change % 1st–2nd goal	35	35.5	19.157	–1.696	0.090
Team A line change % 1st–3rd goal – Team B line change % 1st–3rd goal	35	224.5	41.026	0.865	0.387
Team A line change % 2nd–3rd goal – Team B line change % 2nd–3rd goal	35	142.5	28.553	0.946	0.344

Table 6. *Wilcoxon signed-rank test results on line change percentages as variables. Source: own creation.*

6.4.3 CLUSTER ANALYSIS RESULTS

As seen in Table 7, the K-means cluster method could discern two clusters. In both clusters, Team B had weaker line strengths at every goal in the three-goal events, which meant that the first goals scored by Team B were against stronger opponents. The second and third goals were scored by Team A, which had stronger lines on ice compared to Team B. Additionally, in both clusters, Team A's line strengthened from the first goal to the third goal. This phenomenon showed antifragile characteristics, where the first goal acted as a stressor that triggered Team A to send stronger lines that allowed it to score the second and third goals. Based on the cluster centres, two main cases were identified. The first cluster showed a big difference between the line strengths of Teams A and B, while the second cluster showed almost identical line strengths.

Variable	Cluster 1 (n = 15)	Cluster 2 (n = 20)
First goal Team A average strength	22.2	–4.3
First goal Team B average strength	9.1	–4.2

Second goal Team A average strength	23.4	–0.3
Second goal Team B average strength	5.7	–6.0
Third goal Team A average strength	26.1	1.4
Third goal Team B average strength	3.8	–5.1

Table 7. *K-means cluster analysis and final cluster centres based on the six line strength variables. Source: own creation.*

6.4.4 ANTIFRAGILITY RESULTS

Antifragility was found in cases wherein Team B gained the lead or had a two-goal lead after the first goal of a three-goal event.

There was no antifragility in 13 games. Type one antifragility was found in 15 games, while type two antifragility was found in six games. These complex behaviours, which resulted from cooperation within the team, were found to be an emergent characteristic, as evidenced by Team A's strengthening of the lines after a goal from Team B.

Multiple assists were made on antifragile goals: antifragile behaviour type one assists mean (n = 16): 3.31; antifragile behaviour type two assists mean (n = 6): 4. The result supports our assumption that antifragile behaviour is related to high cooperation within the team. Convexity is again supported, as the stressor goal might have caused the team to increase the level of cooperation through the unification effect to beat the opponent.

6.5 DISCUSSION

The complex behaviour of ice hockey teams can easily be captured when specific performance measurements are collected. In Hungary, these data are available even for youth sports, although they are disorganised since players, parents, and coaches are the only ones interested in information about individual and team performances. The results of our cluster analysis revealed that an optimal amount of stress (Hill et al., 2020) cannot be calculated using the data, as it would only be possible if one cluster could be found. However, a trend was found in which Team A strengthened its line on ice after the first goal in the three-goal events. Three-goal events mostly occurred in the last six seasons of the study period; it may be due to increased competition in the league and advanced expertise shared by players or coaches. The teams

showed different involvement percentages in the three-goal events, which may be the result of high roster changes between and during the seasons. Most three-goal events occurred in the first period of the games, followed by the second period. Few events occurred in the third period. The nature of professional ice hockey supports the findings, as teams are under constant pressure to adjust between games; otherwise, the opponents start the game with a significant advantage. In addition, the first period is usually when teams try to find ways to exploit their opponents, resulting in three-goal events. Majority of the three-goal events occurred when Team A was the away team, which may be due to multiple reasons. First, they were playing at an unfamiliar ice rink, presenting increased adversity, which might trigger more antifragile behaviours (Kiefer et al., 2018). Second, they faced less pressure from the management and the fans. The line strengths of Teams A and B were calculated from individual season performances. Results revealed that Team A tended to increase the line strengths on ice after allowing the first goal to Team B, and large differences were discovered between the line strengths of Teams A and B. The Friedman test discovered that the teams played on equally strong lines when the first goal occurred, but there was a bigger gap between the two lines when the second and third goals occurred. The correlation analysis indicated strong correlations between Team A's three line strengths and Team B's three line strengths separately, but no cross-correlation between the groups was found. This result was expected, as the means of the line strengths suggested that the line differences were assumable. The Wilcoxon signed-rank test revealed no significant differences between the line change tendencies of coaches in Teams A and B. The K-means cluster analysis resulted in two distinct clusters, making it impossible to identify the optimal stress load to trigger antifragility. The three-goal events were divided into three categories: 1. no antifragile behaviour, 2. antifragile behaviour type one, and 3. antifragile behaviour type two. Convexity, and therefore antifragility (Taleb, 2012a), was identified in situations where Team B gained the lead with the first goal of the three-goal event (type one), or Team B had a two-goal lead after the first goal of the three-goal event (type two). In both cases, high cooperation was found by measuring the number of assists made on the second and third goals, which fits our assumption that antifragile behaviour is a result of high-level cooperation.

6.6 CONCLUSION

Although convexity, and therefore antifragility, can be proven in 22 out of 35 cases, these behaviours are extremely rare as the total games studied were 2,183. Teams have access to many tools to beat an opponent. This includes antifragile behaviour, as convexity can be created in ice hockey games. Antifragility was found in cases when Team B had one- or two-goal leads after scoring the first goal of the three-goal events. When Team A strengthened the line after the first goal, the situation became convex and therefore antifragile. Coaches and players should be educated on how to create these situations to increase the number of antifragile behaviours, as such modern phenomena are welcomed by all professional and youth ice hockey stakeholders.

7. SUMMARY

Studying and researching ice hockey offers a great context for finding novelty, based on the complexity of the game, and the visibility and measurability of results. Although the measures of performance are multilayered containing personal- and team results, the synergy between players can also be extracted from the data available. Professional level ice hockey is data rich, as fans are quite interested in having deep knowledge about their teams and the players. Although sport analytics and sport statistics are constantly innovating tools to enhance the understanding of the game, these methods are resource- and expertise expensive. Although the idea that teams with more resources are more likely to win appears reasonable to consider, it was concluded by research that in the case of winning, the salaries of the players do not determine the outcome of the game, only the quality of players and the quality of coaching that determines which team wins (Berri and Jewell, 2004). This phenomenon supports our five-factor model as it deals with two participants: the coach and the team, and also support my research process by highlighting the fact that sport science is the area in which the performance of a given team is a central motive.

The intention to create a model that is capable of covering the key factors that define high performance of a team led me to clearly demarcate the boundaries of what is dealt with and what is not dealt with in the model. The main aim behind this was to create the model in such a way that enables it to be handled easily, as practitioners are bound to use it in practice. This may represent a limit to the current research.

Innovation turns out to be a guarantee of the evolution of the field of ice hockey. Innovation does not always happen in the offices or the coach's room, a creative player is a constant innovator on the ice, creating temporal disequilibrium or non-equilibrium states. In my dissertation, I refer to equilibrium as a state in which convergence functions towards homogeneity, meanwhile, I use non-equilibrium as the state in which divergence functions towards heterogeneity. These non-equilibrium states include periods of chaos along with stochastic ones. An ice hockey game has a wide possible variation of events, including non-equilibrium states. These divergent states may give birth to high individual performance resulting in scoring which contributes to the team performance as well. Non-equilibrium seems to dissolve team unity through divergence when found in a team, although willingness to

perform individually in ice hockey is only possible through playing in a team. On another level, when non-equilibrium is found in a game between two teams, their aims might differ in preference and quality. In equilibrium settings, both teams have the same aim, namely the winning the game. Non-equilibrium offers the chance for both teams to have their characteristics ("team personalities") included in the aims and their actual gameplay. A more innovative team is capable of creating long-lasting non-equilibrium states, making the opposite team rethink the aims for the gameplay. Imagine a game in which both teams have the same goal (which means equilibrium): to win the game, at all costs. The innovation competition starts with the game, and the more innovative team wins. In a non-equilibrium setting, in which there is measurable difference between the teams, only the "winning the game" aim is common, every other aim differs, creating an open system out of a closed one. The equilibrium-based idea of team competition, therefore, is not capable of describing the real-world phenomenon in which asymmetry between competing teams or competing players are present. Non-equilibrium as a stable state is understood such that the two opposing teams do not converge towards an equilibrium. Convergence would include the exchange of game knowledge between the teams. An inherent characteristic of non-equilibrium state is that the state is held between two boundaries from two directions. The boundary towards equilibrium is easy to go to, while the opposite direction more difficult, and it gets harder exponentially with every step. A question arises whether maintaining a non-equilibrium state is worthwhile for the participating parties. Does it contain benefits that are more valuable than the energy spending on maintenance? Energy spending is found in the case of equilibrium as well, as competition has energy costs as well through the constant need for innovation. It is important to mention a situation in which a team or player constantly innovates and has a great innovative capacity and it might create a stable non-equilibrium state on the long term which depends on the direction of the movement of the team or the player tends to. If the same aim is present for the teams (winning the game) or players (competing to be the best player in the team), the needs of the competing parties are satisfied by a different extent. In an equilibrium state, the satisfaction of the parties is equal.

Professional ice hockey inherently creates non-equilibrium states as the distinction between the winner and the loser team, or the competing players is done in each game. The proportion of satisfactory impulse for every competitor is different. The winner is tending towards the winner's section on the landscape, while the loser tends to the loser's section, creating

divergence as a result of interaction between the competing parties. Therefore, non-equilibrium is a dynamic state in which competitors are constantly moving in a divergent fashion. In such a system, two attractors seem to exist, one which attracts loser teams or players, and one which attracts winners. The aim of a team in a championship is to get as close to the winners' attractor as possible, and to push other teams towards the losers' attractor. Innovativeness towards diverging directions enlarges the landscape, creating more room for movement for all competitors, and might increase the chance for a new attractor to be identified and formulated on the landscape, which would serve as a base for fundamentally renewing competition-based professional sports.

Innovations mean movement on the landscape. Those that are convergent towards an equilibrium point in which the interactions happen, are commonly found in professional ice hockey, although in the case of non-equilibrium, the divergent behavior of competing players increases the distance traveled for competitive interactions. Although equilibrium seems to be the key for growth, its opposite is true, as non-equilibrium is the only viable way to enlarge the landscape. In addition, the field of opportunities increases through divergence to experience success on the short term as well. In equilibrium settings, the landscape could be enlarged as well, but since uniformity is present between the participants of the system, a new participating agent has to go through a learning process to be able to compete. In case of divergence, the only similarity is the fact that a new agent is following a divergent path, but the learning process is unique and no copy mechanisms are present to represent competitiveness on the landscape. Competition, therefore, is transformed into a process in which the distances between participants on the landscape are shortened, enabling competition to transform from a low-dimensional phenomenon to a high-dimensional one. Cooperation is not imaginable without competition and competition requires the participants to adopt to the same rules which inevitably means cooperation. Although the same rules apply to all competitors, the quality of knowledge of these rules show inequality in real-world competition situations. An important consequence of equilibrium thinking is the fact that during and after a game, it is a known phenomenon that as a result of a closed-system context of the competition, the rules of a closed system dynamics apply and information is exchanged between the competitors, equalizing the difference between them. These dynamics mean that the distance between the competitors decreases, and might work against the attraction forces of the winners'/losers' attractors. In an

open-system, competition is ruled by creativity as a tool to use additional input energy. It is a characteristic feature of open systems that a stable non-equilibrium state might evolve.

As shown above, the conflicting interests of competitors create a closed-system context, but it cannot be stated that the resources are always scarce, they are rather limited. Scarce resources are stronger attractors than limited resources, which explains why there is room for ethical and sportsmanlike behaviors even in professional sports. The use of these behaviors is two-fold, they can be advantageous- and disadvantageous as well, depending on the dynamics of a given situation. A non-equilibrium state in this context means different Machiavellianism/ Sportsmanship ratio on the landscape, and through divergent dynamics, this ratio may shape the process of development. It can hardly be stated that an ice hockey game behaves like a closed system. The number of goals each team can score has a wide spectrum, although winning/losing is the part in which closed-system characteristics appear. From the final results' perspective, the game can only be considered in case of professional ice hockey as a process towards non-equilibrium. Besides physiological processes, the final results have different impacts on the psychological status of the participants. Focusing solely on winning/losing creates a closed-system behavior as mentioned earlier, as it contains binary possible feedback loops: positive for winning, negative for losing. These dynamics result in maximal order, and minimal entropy in the system. It is questionable though, whether an ice hockey game should work against the arrow of time, originated in the second law of thermodynamics. The arrow of time concept declares that in every closed system, entropy is working towards being maximal as time goes by. The attractiveness of ice hockey is found in the fact that even when considering professional sports, high performance is related to how the players plays the game. They can immensely enjoy playing, or they treat ice hockey as a job. All this depends on personal characteristics. The main difference is that playing as a joyful activity is mainly associated with childhood, while working as a player is associated with adulthood. The natural process of human beings is that they play a lot of games playfully develop, and become adults when the need for playing decreases. Playing ice hockey demands from adults to play as children again, therefore, to move against the arrow of time. Once again, considering the landscapes helps us to understand the effects of playing ice hockey. When a professional adult player goes on the ice and plays a game, a phase transition happens: in order to play the best game possible, the player must reach out for the inner child as it propels to high performance with the probability of winning. The distance between the inner child and the adult behavior increases through

divergence when we consider a diverging, non-equilibrium process. This is an alternative explanation of why professional ice hockey players stop playing when they become older, in addition to the onset of physiological and biological processes. Therefore, the non-equilibrium state by its nature helps players to avoid getting stuck in the situation in which they play ice hockey solely as a working activity through the constant, divergent innovation process. Contrary, in case of equilibrium, biology is the bottleneck the player faces. It means that supporting psychological processes are prioritized, resulting in a narrower landscape. Comparing the wide- and narrow landscapes, the psychological aspect suggests that the wider landscape is preferable to the narrow one, as the extended room in a wider landscape offers a chance of more emerging patterns, meaning less monotonous repetitions in the mental processes. Therefore, if a player wants to maintain his/her wellbeing, a divergent development is to be chosen towards a non-equilibrium state. In the case of a coach, the same suggestions apply: development towards a non-equilibrium state offers the for the coach chance to avoid becoming burnt out. It also offers the chance for the coach to provide a sufficient variety of activity options when coaching players. The increased broadness of landscape offers more bifurcation space to happen, and might enlarge the possibility of new attractors to be found. Equilibrium is itself an attractor. In non-equilibrium, the constant divergence enables the participants jumping from attractor to attractor, including meta-stable and local equilibrium points. The continuous discovery of attractors makes bifurcations happen, and ensures development from the psychological aspect. Being attracted by a new attractor offers the possibility to experience new phenomena understood as learning from the attractor itself and from the other attracted objects through interactions. In the case of attractors having overlapping basins, meta-stable dynamics will happen when switching from attractor to attractor. Being in such an overlapping basin area is itself a non-equilibrium state as well. The exploratory behavior of the team and the coach, which is a direct consequence of divergency, is to be focused towards the winning area of the landscape. This means that the aim of the team is to be constructed in each game at least to overlap with the winners' attractor basin. Closed-system competition for winning is, therefore, seen as an activity of investing more effort to be attracted by winners' attractor than towards the losers' attractor. Meanwhile, a non-equilibrium system with its inherent openness is characterized by forces of undiscovered attractors outside the boundaries of the landscape. As the information contained in the yet-to-be explored attractors, the size of their basins and the force of attraction are not known such that unpredictability

becomes a characteristic feature of ice hockey games of teams following the non-equilibrium concept. The experience of the coach and the players are translated into the breadth of the landscape and knowledge about the discovered attractors. Although the two known attractors of winning and losing are highly known by professional players and coaches, the way of moving closer to either of the two might be on a not yet discovered pathway. The new pathways offer the chance to be under the effect of not-yet discovered attractors, offering novel information through the interactions with the basins and the other attracted objects.

It is easy to understand that if we consider ice hockey games as open systems, many characteristics emerge including exploratory behavior, effects of unknown attractors and non-equilibrium dynamics. A question remains whether a third attractor may be found among the known winning and losing attractors. Such an attractor is to be created in a way that the needs of all participants are satisfied and the attractor is stable and attractive enough to become a competitor of winning and losing. This requires the examination of physiological and psychological effects of winning and losing. An attractor that supersedes winning and losing in the process of satisfying needs on a higher level, might offer a viable way for developing professional sports from a wellbeing perspective.

Winning and losing are understood as positive and negative feedbacks for performance, and in case of a closed systems thinking, it has inevitable effects on the psychological processes of the participants. Maslow's pyramid is used to understand the dynamics of the two types of feedbacks. In the case of an ice hockey game, all the participants are aiming to have all the levels of the pyramid satisfied. The basics part is more or less satisfied if a team is not short of players, and the load/rest ratio is within a range that supports normal physiological and psychological processes. The preparedness of the players is a strong influencing factor when considering the needed ratio. The first level of psychological needs of the players is inherently satisfied if a team has a friendly and supportive culture the players or a coach belong to. The satisfaction of esteem needs is the stake of the game the team plays. By first sight, competition is considered as an activity to satisfy the esteem needs in an environment characterized by resistance to do so. Although real world competitions are natural behavior of animals and Darwinism is still the appealing paradigm, human beings might also have a need for competition satisfying the instinct to compete. As we consider divergence as a natural activity

of non-equilibrium systems, the strength of this instinct and the satisfaction of the related needs are on different levels in every human being. The method of satisfying the esteem level of the pyramid is different for each person as well: some focus on the visible results, some focus on the feedbacks of teammates and the coaches, some just rely on their inner voice. The theory of the pyramid includes these methods. If we consider the ice hockey game as a real-world competition situation as it is now in professional sports, we need to assume that the competitors have the same preferences and methods of needs satisfaction. As a consequence, a real-world competition must take place in a system that is in equilibrium. In a divergent non-equilibrium system, the fulfillment of the needs of the participants rely on the divergence supporting activity of the others involved. In such a system, it is assumed that the diverging participant will find new attractors and, as a consequence of landscape broadening, room and knowledge for satisfying esteem and higher-level needs. The pyramid model is hierarchical, meaning that the higher-level needs are satisfiable only in case the lower levels are satisfied. Therefore, an improper load/rest ratio has negative consequences on the psychological and higher-level needs satisfaction, which makes overloading the players and the coach. This situation must be avoided activity to ensure wellbeing. It clearly emerges that the coach and the players are moving together on the landscape, otherwise both parties would have to spend energy and time to move towards each other in order to work on the practices and the games in a cooperative relationship.

The reason behind the stability of non-equilibrium states when considering ice hockey game participants is the benefit of diverse structures in the system, as it offers a base for psychological wellbeing. In the psychological sense, the diversity of the players and coaches, and their development are one of the most important pillars of wellbeing. The participants of an ice hockey team are co-developing. A divergent development trajectory is in itself an attractor. If all the participants are diverging, the landscape will become charged and the forces of many unseen attractors might affect the participants. The attraction force of unseen attractors offers novel information, which is a base of development, especially in a mental sense.

It remains unclear whether winning and losing attractors have fixed positions on the landscape. In case of equilibrium settings, their position is assumed to be known to the participants of the game, while in non-equilibrium, their respective positions are assumed not to be known. Therefore, in case of non-equilibrium, team meetings are to be carried out in a way that triggers

exploratory behavior of all the participants. It is to be done through getting the participants ready to be open to the forces of attractors, and equip them with psychological characteristics that enable them to find and drift towards the winning attractor, while opposing the force of the losing one. In equilibrium settings, the team meetings have the function of identifying the most optimal solution towards winning the game where wellbeing is the stake of the game. Therefore, the fundamental difference between the two contexts lies in the fact that while in equilibrium settings, the exploratory behavior is done within the team through meetings and psychological wellbeing is the reward of winning, non-equilibrium settings require the team to be exploratory on the game itself on a bigger scale, and wellbeing originates from this exploratory process. This supports the idea that non-equilibrium is a stable state of open, while equilibrium is a stable state of closed systems. Wellbeing as a reward has a temporal effect on the global wellbeing of the participants, while exploratory behavior might become an internalized life skill the participant continues to use outside the boundaries of ice hockey. Non-equilibrium systems support the idea of having different personalities in a team, and also support the idea that external information should be introduced as a new attractor through novel knowledge. It is then promoted to let players and coaches of the team be not exclusively a specialist of ice hockey, but be an explorative person who transfers precious knowledge among various real life systems participating in. These multi-faceted players and coaches are innovators in the systems they participate in.

Divergence and innovation are seen as related processes, as divergence is in itself an innovative process, considered as a characteristic property of a person. It is proposed that innovativeness as an attractor is a viable competitor of winning, and winning through innovation is seen as a throughout solution for player and coach development, maximizing their wellbeing. Winning without innovating appears not to be contributing towards the wellbeing of participants of a game, and losing with innovation is seen as an activity that counterweights the effect of losing. Losing without innovating is the worst-case scenario, resulting in the lack of acquiring both wellbeing and life skills. Also, playing against an opponent who wins through innovation has a teaching effect towards the loser team.

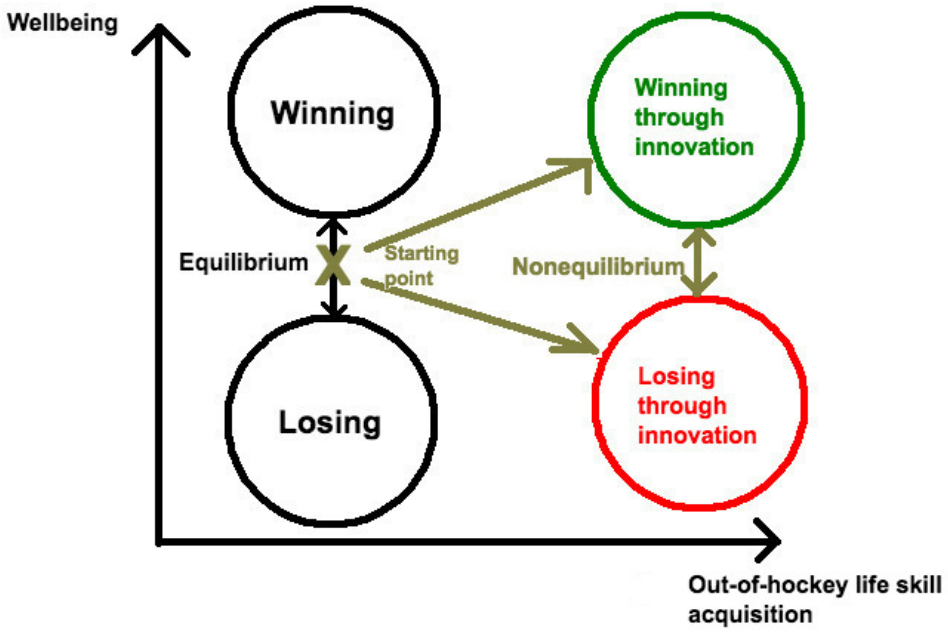

Figure 1. From equilibrium towards non-equilibrium attractors landscape in an ice hockey game. Source: own creation

In an equilibrium context, the primary aim is winning and the secondary aim is innovation. In the case of non-equilibrium states, innovation is the primary aim and winning is the secondary. Personal development includes trial-success and trial-error processes, and is defined as the development of unique characteristics of the participant of the game. As seen in Fig.1, winning through innovation is a longer distance to travel from the starting point than the winning attractor, which requires more energy. If the aim of a participant is to win the game the most efficient way, equilibrium thinking is to be used, serving a short-term goal. If another dimension (in this case, out-of-hockey life skill acquisition) is considered important, more energy is to be spent to win through innovation. Innovation appears to be an important phenomenon in the cases of equilibrium and non-equilibrium thinking as well, but the aim is different. In the case of equilibrium thinking, the aim is to win with the help of innovations, but this innovation is copied by all the other participants, creating uniformity. In the case of non-equilibrium, life skills that are utilizable outside ice hockey settings are to be learnt. The more out-of-hockey life skills get acquired, the more tools a participant has for solving real-world problems. Continuous innovation might include exploring/learning elements that makes the personality of the innovator more unique. Uniqueness includes the fact that the more developed and unique a

personality is, the less competitors they have, which results in easier access to decisive psychological resources.

A developed personality (which in the case of non-equilibrium means uniqueness based on divergence) is seen as a preferred characteristic of the participants, as internal competition of an ice hockey team is considered to be obsolete for team performance. Uniqueness of the personalities does not necessarily mean that the team lacks common goals. A team with more developed and unique personalities (i.e., a larger set of possible problem solutions) is likely to win more ice hockey games. Developed and unique personalities are understood as differing elements of a system, and as their characteristics differ, the synergies formed through their cooperative interactions are likely to be unique as well, considered as a non-linear process towards increased uniqueness. Uniqueness imposes new perspectives regarding interactions, as unique personalities can only interact through non-equilibrium characteristics, as their uniqueness is stabilized by continuous innovation. Therefore, the interactions are to be done in a way that open system characteristics are present, otherwise the participants are creating competitors for themselves, and as mentioned earlier, might risk the emergence of harmful competition. A question remains whether all the unique personalities must contain competitive traits, or some of them are efficient without those traits as well. This is a question of how strong the animalistic instincts are in a given participant. Without the competitive trait, one may place emphasis on the innovation part of the winning through innovation solution, and function likewise in their teams. The divergent and unique personality concept accepts this solution, although the process of continuous divergence might become competitive if the personality interacts with another that has similar characteristics and by some reason an attractor offers resources only for limited participants. Winning and winning through innovation are examples of these kinds of attractors.

There is a great chance that divergent participants will face less competition than equilibrium concept participants. Unique participants are born by having a unique orbit with a unique set of attractor forces experienced through divergent behavior. An ice hockey game in its totality is a complex phenomenon, enabling multiple levels of needs to be satisfied, including the exploration of known and not-yet-known attractors. The encouragement of exploratory behavior is a must if we want participants to develop their personalities towards uniqueness. The upside of this process is that the more unique a personality is, the less competition it faces,

while the downside is that leaders having unique personalities in their teams require meta-level knowledge to be successful.

Equilibrium in an ice hockey game is a phenomenon that would require the participants to have the same quality and quantity of knowledge, skills and personality traits, which appears to be insufficiently explaining the game, as the game is mostly characterized by not-equal forces and capabilities of the participants. It seems reasonable to prepare the team for an equilibrium concept in which homogenous team members are cooperating. However, such a team is easy to predict as if one participant is explored, the whole team is explored to, allowing the opposite team to get to know the strengths and weaknesses in a short time. Non-equilibrium concept following teams, therefore, are in advantage based on the deepness of explorable participant traits. The question whether the exploration of novel patterns through interacting with unique personalities can possibly satisfy a lower-level need on Maslow's pyramid than the esteem level satisfied by winning is to be further examined. Divergence into non-equilibrium settings offers the chance of satisfying the top level of the pyramid, while a convergent concept focuses only on the esteem level satisfaction. This creates a basic difference in the behavior of the teams. The non-equilibrium concept following team can reach the highest level of psychological needs satisfaction, and the innovation process counterweights the effect of losing. The equilibrium concept following team rarely satisfies the top level. The non-equilibrium concept following team is, therefore, characterized by offering a more complete psychological satisfaction, meanwhile equilibrium concept follower team participants experience the top level of the pyramid through disequilibrium states characterized by temporality by short-time innovations. Therefore, the non-equilibrium concept by nature offers a wider range of needs satisfaction compared to the equilibrium concept.

The movement of the team on the landscape is affected by the personalities of the team captain and the assistant captains, based on their attractor behavior. It is the team's tool at hand to trigger nonlinear proceeding towards uniqueness. Divergence is present internally but also externally when considering a game from a team's perspective. Both are governed by exploratory behavior. The ever-increasing landscape is a source of novel information entering the system, and through the innovation process, the new information is built into the behavior of the participants of the game.

The equilibrium concept offers the chance for a team to be compact and unified. Such a team can react to attraction forces faster than a non-equilibrium concept follower team. The latter shows a growth rate on the landscape, resulting in a wider coverage, characterized by less outcome predictability. It is important to mention that teams on the landscape are attractors as well, and a more concentrated, equilibrium concept following team might provide a stronger attraction force than a non-equilibrium concept follower team. A game between the two types of teams is itself a non-equilibrium situation, therefore a non-equilibrium concept following team creates a situation in which the characteristics quickly influence the environmental settings. From the opposite side, the equilibrium concept following team's interest is to reduce the heterogeneity and pull the other team onto the equilibrium orbit, which is understood as a transfer of equilibrium onto the other team. Although it seems a frightening novelty, it is reasonable to reconsider the winning-losing dichotomy into winning-through-innovation and losing-through-innovation in light of advancement of scientific knowledge applied to professional sports. Although it seems reasonable to reconsider the dichotomy, the former is the main characteristic of professional sports, and it functions as a method of satisfying esteem needs through comparison. It is proper to say that there are people who find this method satisfying, and their esteem needs are best fueled by participating in winner-loser competitions. We then arrive to the question whether this concept contributes to the development of social behavior, at least through satisfying the esteem needs of the winning team. The spectators of the games are once again subject to comparison as the participants of the game compete in a fierce manner that a spectator would not do, therefore, the spectators might see a pattern that is satisfying on the instinct level, but not much accepted by the societal norms. Therefore, the wellbeing of the spectators is increased without becoming fierce competitors themselves. It does not seem to differ much from ancient Rome's gladiator games, except the fact that competition is softened in a way to avoid human injury or death. The main idea behind this phenomenon is that spectators want to see the totality of human capabilities which they rarely witness in their lives.

It is apparent now that a non-equilibrium concept following team is more innovative in sum compared to an equilibrium concept following one, which serves as a pattern of learning for the spectators of the game as well. An equilibrium-based competition offers less lasting innovation

and more homogeneity, which results in a unification effect on the spectators as well. It offers suppressed innovation which does not allow the communities to exploit the innovation potential that is reachable in the case of non-equilibrium settings. Divergent behavior in this light is considered as an activity to innovate in a way that a participant finds or creates the new knowledge that satisfies all of his/her psychological needs, therefore, the development is done through innovating in a personal way, using the personal innovation to contribute to the aims of the team. Thus, this contributes to the development of society on the whole where the wellbeing of the participants is supported as well. The aims for such a developing society vary based on the circumstances and the mix of cultures that have a wide range of aims. It is, therefore, suggested that the methods of professional ice hockey be adjusted in a way that it should not serve the needs of the competitive players' only, but should offer a throughout method to develop the participants in a way that is beneficial on a larger scale. Although there are a few cultures in which this already happens, there are sports cultures, where the culture is based on competition as a preferred phenomenon. It is to be suggested that countries should not follow the competitive culture and should not copy those mechanisms, which create competition without reaching a system with innovation potential.

The misbehaving of a participant takes the same form as the divergence process, although their aims differ. A non-equilibrium concept following participant is interested in expanding the landscape, acquiring novelty and presenting it as an innovation which supports the development of a unique personality. A misbehaver aims at creating their own rules and making them persistent in the system. Misbehaving inherently involves competition, as the basic idea behind it is that the creation of one's own rules is done in an environment that opposes it. This process requires competition between the top-down and the bottom-up processes, and the misbehaver wins if their bottom-up process wins and stays permanent. In the non-equilibrium concept, the divergent behavior is not done against opposing forces, however, the ultimate aim to win through innovation requires more energy and time than simple winning.

In the light of complexity, it is assumed that all the participants of the games want to experience the full range of what a game can offer, therefore, in equilibrium settings, the emergent phenomena of the whole team are likely to be characterized by non-equilibrium. On the other hand, the emergent phenomena in non-equilibrium settings are likely to be characterized by

equilibrium. The former type offers team development over personal development, while the latter offers personal development over team development. As mainly in professional sports, the teams are only temporal creatures, therefore, it appears to be more beneficial to prefer non-equilibrium players with emergent characteristics of equilibrium over the opposite case.

Concept	Equilibrium participants, emergent characteristics of non-equilibrium	Non-equilibrium participants, emergent characteristics of equilibrium
Dominant life skills pattern offered	Teamplay skills development	Personal development

Table 1. *Life skills patterns offered by differing characteristic systems. Source: own creation*

The crossing of types of the emergent phenomena is considered as a result of complexity, together with the basic human need for variance of life experience, which is easily understood as the key element of adaptation for survival. The two cases are handled separately: in type one, the participant learns to be in equilibrium alone, while they need other people to create non-equilibrium. In type two, people are needed to create equilibrium. Type one participants are characterized by being balanced with small, temporal conflicts on the inside, while having out-of-balance, conflicted relationships. Type two is characterized by conflicting inner behavior with balanced, conflict-free relationships. This dichotomy is the direct result of the complex effect that an equilibrium, or a non-equilibrium concept may have on the participants. The two categories are the two opposite ends of the scale, as in real world situations, the elements of the categories are mixed for every participant. If a team consists of homogeneous players, it might be considerable gain to look for a coach that offers the opposite characteristics the players represent. Such a decision would offer a high amount of additional information and knowledge transfer process. Such a decision, at the same time, is considered risky, but ensures change and triggers adaptivity in the participants. Although it seems natural, we do not want competition between the coach and the team, as innovation would be suppressed in such a situation, which would hinder both personality and team development.

The consequences are clear: the participants of an ice hockey game are in need of personal development as well, as playing ice hockey on a professional level for a lifetime is not possible. Non-equilibrium is not yet a widely applied concept. The teamplay skills of current ice hockey players are extraordinary, as the equilibrium concept offers development in that direction. In order to maximize the wellbeing of the participants, the non-equilibrium concept is to be adopted and followed, through which the aim of the team is to win through innovation. This process ensures the development of uniqueness in the personalities of the participants, which lasts long after the professional ice hockey career and contributes to high wellbeing through the large variety of patterns as well.

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9. APPENDIX

1. Schutte et al. (1998) - Emotional Intelligence Scale, validly translated into Hungarian (5-item Likert scale):

EI1: I know when to speak about my personal problems to others

EI2: When I am faced with obstacles, I remember times I faced similar obstacles and overcame them

EI3: I expect that I will do well on most things I try

EI4: Other people find it easy to confide in me

EI5: I find it hard to understand the non-verbal messages of other people*

EI6: Some of the major events of my life have led me to re-evaluate what is important and not important

EI7: When my mood changes, I see new possibilities

EI8: Emotions are one of the things that make my life worth living

EI9: I am aware of my emotions as I experience them

EI10: I expect good things to happen

EI11: I like to share my emotions with others

EI12: When I experience a positive emotion, I know how to make it last

EI13: I arrange events others enjoy

EI14: I seek out activities that make me happy

EI15: I am aware of the non-verbal messages I send to others

EI16: I present myself in a way that makes a good impression on others

EI17: When I am in a positive mood, solving problems is easy for me

EI18: By looking at their facial expressions, I recognize the emotions people are experiencing

EI19: I know why my emotions change

EI20: When I am in a positive mood, I am able to come up with new ideas

EI21: I have control over my emotions

EI22: I easily recognize my emotions as I experience them

EI23: I motivate myself by imagining a good outcome to tasks I take on

EI24: I compliment others when they have done something well

EI25: I am aware of the non-verbal messages other people send

EI26: When another person tells me about an important event in his or her life, I almost feel as though I have experienced this event myself
EI27: When I feel a change in emotions, I tend to come up with new ideas
EI28: When I am faced with a challenge, I give up because I believe I will fail*
EI29: I know what other people are feeling just by looking at them
EI30: I help other people feel better when they are down
EI31: I use good moods to help myself keep trying in the face of obstacles
EI32: I can tell how people are feeling by listening to the tone of their voice
EI33: It is difficult for me to understand why people feel the way they do*

2. Wagnild and Young (1990)'s Resilience Scale, validly translated into Hungarian (7-item Likert scale). Used with purchased license from The Resilience Center (PO Box 313, Worden, MT 59088-0313).
RES 1: When I make plans, I follow through with them.
RES 2: I usually manage one way or another.
RES 3: I am able to depend on myself more than anyone else.
RES 4: Keeping interested in things is important to me.
RES 5: I can be on my own if I have to.
RES 6: I feel proud that I have accomplished things in life.
RES 7: I usually take things in stride.
RES 8: I am friends with myself.
RES 9: I feel that I can handle many things at a time.
RES 10: I am determined.
RES 11: I seldom wonder what the point of it all is.
RES 12: I take things one day at a time.
RES 13: I can get through difficult times because I've experienced difficulty before.
RES 14: I have self-discipline.
RES 15: I keep interested in things.
RES 16: I can usually find something to laugh about.
RES 17: My belief in myself gets me through hard times.
RES 18: In an emergency, I'm someone people can generally rely on.
RES 19: I can usually look at a situation in a number of ways.

RES 20: Sometimes I make myself do things whether I want to or not.

RES 21: My life has meaning.

RES 22: I do not dwell on things that I can't do anything about.

RES 23: When I'm in a difficult situation, I can usually find my way out of it.

RES 24: I have enough energy to do what I have to do.

RES 25: It's okay if there are people who don't like me.