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The problem of uncertainty and risk as a subject of research of the Nobel Prize Laureates in Economic Sciences

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Abstract

Aim/purpose – The main aim of the present paper is to identify the problem of uncertainty and risk in research carried out by the Nobel Prize Laureates in Economic Sciences and its analysis by disciplines/sub-disciplines represented by the awarded researchers.
Design/methodology/approach – The paper rests on the literature analysis, mostly analysis of research achievements of the Nobel Prize Laureates in Economic Sciences.
Findings – Studies have determined that research on uncertainty and risk is carried out in many disciplines and sub-disciplines of economic sciences. In addition, it has been established that a number of researchers among the Nobel Prize laureates in the field of economic sciences, take into account the issues of uncertainty and risk. The analysis showed that researchers selected from the Nobel Prize laureates have made a significant contribution to raising awareness of the importance of uncertainty and risk in many areas of the functioning of individuals, enterprises and national economies.
Research implications/limitations – Research analysis was based on a selected group of scientific research – Laureates of the Nobel Prize in Economic Sciences. However, thus confirmed ground-breaking and momentous nature of the research findings of this group of authors justifies the selective choice of the analysed research material.
Originality/value/contribution – The paper includes a selection of research achievements in uncertainty and risk of the Nobel Prize Winners in Economic Sciences previously not presented in scientific papers.

Keywords: risk, uncertainty, Nobel Prize, economic sciences
JEL Classification: A12, B2, F01.

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1. Introduction

With the rapid economic, technological, social and commercial changes, uncertainty and risk started to appear in all spheres of activity of national economies and societies at macroeconomic level and of economic operators and entities at microeconomic level, thus becoming subject of research in numerous scientific disciplines and sub-disciplines (Banse & Bechmann, 1998; Elahi, 2013; Schilirò, 2017; Zinn, 2006, 2010).

As a result of this approach to analysis of uncertainty and risk these terms have become interdisciplinary ones determining process of efficient management (Tchankova, 2002) of organisations, societies and countries.

Due to the high importance and pervasiveness of uncertainty and risk in economic sciences (Zalega, 2016), these issues are often analysed in the scientific literature (Fleurbaey, 2018), also in works of eminent scientists whose ground-breaking achievements were recognised with the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel.

A research gap has been identified in the scientific literature regarding the lack of selection from the research of Nobel Prize Laureates of achievements regarding the role of uncertainty and risk in economic sciences in the form of one synthetic scientific text. The purpose of this text is therefore to identify this issue and its analysis broken down into disciplines/sub-disciplines of economic sciences represented by awarded researchers, and thus to fill the identified research gap.

The paper consists of four essential parts. The first one sketches the origins of research in risk and uncertainty in the theory of economy. The second part identifies all Nobel Prize Laureates in Economic Sciences since 1969 and categorises their achievements. Next, Nobel Prize Winners who carried out scientific research related to uncertainty and risk are identified. The paper finishes with a characteristic of research achievements of selected Nobel Prize Winners by disciplines of economic sciences.

2. Theoretical background

Terms of uncertainty and risk were introduced to the world economic terminology by Cantillon in the 18th century (Cantillon, 1755). What he noticed was the insecurity inseparably accompanying economic activity and broad impact risk had on revenues. Furthermore, historical research analysis by Laplace

and Poincare allowed to notice, i.a. causal relationship in risky economic decisions, thus becoming the starting point for developing later methods and techniques of analysis as well as uncertainty and risk evaluation in activities of economic operators (Kaczmarek, 2010).

The growing importance of uncertainty and risk in the theory of economics was also mirrored in explaining the principles how markets and economic operators function. Possibilities to anticipate economic phenomena and to protect against their negative impact started to become the subject of studies of economists, i.a. Willet, Knight, Keynes (Arrow, 1979). Procedures were formulated both with respect to unexpected and predictable events in order to minimise material damage.

Scientific literature provides examples of analyses of function of uncertainty and risk in many theories of main stream of economics. They include among others:

- choice theory (e.g. Arrow, 1979),
- expected utility hypothesis (e.g. Ellsberg, 1961; von Neumann & Morgenstern, 1947; Savage, 1954),
- theory of rational actions of management units (Gigerenzer, 2002; Simon, 1965).

In the choice theory, key research findings concerning uncertainty and risk as determinants for functioning economic mechanisms come from a series of Arrow's essays (1979). According to the choice theory, it was believed that one of the key problems in conditions involving risk is describing its consequences which are not certain. It was explained that uncertainty of consequences exists in the mind of the person making choice and regulates their actions. The key and principal conclusion from Arrow's research is thesis that in the economic space there are operators burdened with the load of responsibility for occurring risk. These are enterprises taking risk of uncertainty by doing so they suffer unexpected losses of gain unexpected benefits.

Uncertainty and risk also became the subject of research in the process of formulating expected utility hypothesis. It is the so-called Bernoulli's St. Petersburg paradox developed in 1738 that forms the foundation for this hypothesis (Schilirò, 2017). The principle of maximisation of expected utility should be followed by participants of business life who, according to Arrow, in their decision-making processes administer knowledge established with the help of the so-called subjective probability. In such a case utility maximisation principle becomes key criterion optimising choices made in uncertain conditions (Kasprzak,

1979). These are also von Neumann & Morgenstern (1947) who contributed to furthering of the maximisation of utility hypothesis, similarly to Savage (1954) who developed the concept of subjective expected utility taking into account personal probability. Savage's utility theory is experimentally contradicted by Ellsberg's paradox (1961) which shows that choice models cannot be explained with the use of probability of activity evaluation.

Another foundation of theory of economics is the theory of rational actions of management units taking into account uncertainty and risk as impact factors for rationality of individuals or enterprises, that is a microeconomic dimension of business life. Economic phenomena are most frequently analysed with the assumption of limited rationality of human being as a decision maker. This assumption, however, does not undermine rationality of choices but proves more intentional than actual rationality of individuals (Simon, 1965). The rationality theory in the main stream of economics is directly linked to the previously mentioned theory of economic choice which analyses uncertainty of economic phenomena as basic variable. Cognitive aspect of uncertainty started to be included in the choice theory in 1950s, when uncertainty was interpreted as a subjective probability of rationality of economic factors. Attempts to expand this approach in a more objective manner can be noticed, i.a. in Simon's studies (1955) and later in Gigerenzer's (2002).

3. Research methodology

The basic method applied in the research process was the literature analysis with a particular focus on research achievements of the Nobel Prize Laureates in Economic Sciences.

Therefore, the primary source of data comprised the scientific literature from the main stream of economic theory, publications by selected Nobel Prize Winners and biographical entries, and press releases available on the official website of Sveriges Riksbank Prize in Memory of Alfred Nobel.

In the research process the following research questions have been formulated:

- In which disciplines/sub-disciplines of economic sciences are scientific studies on the issue of uncertainty and risk carried out?
- Are there researchers who tackle the problem of uncertainty and risk among the Nobel Prize Laureates in Economic Sciences?
- What was the contribution made by the Nobel Prize Laureates in Economic Sciences to the research on risk and uncertainty?

4. Research findings

4.1. Nobel Prize Laureates in economic sciences

Uncertainty and risk are issues relatively frequently analysed in the works of eminent scientists whose path-breaking achievements were recognised with the Sveriges Riksbank Prize in Memory of Alfred Nobel. The list of all to-date laureates in economic sciences together with the awarded discipline or sub-discipline is presented in Table 1.

Table 1. Nobel Prize Laureates in Economic Sciences

Name	Year	D/s*	Awarded achievement
1	*2*	*3*	*4*
1) Ragnar Anton Kittil Frisch 2) Jan Tinbergen	1969	EC	Development and application of dynamic models for the analysis of economic processes
3) **Paul Samuelson**	1970	EQ	Scientific work through which he has developed static and dynamic economic theory, and actively contributed to raising the level of analysis in economic science
4) Simon Kuznets	1971	GRO	Empirically founded interpretation of economic growth. Developed methods for calculating the size of, and changes in, national income
5) **John Hicks** 6) **Kenneth Arrow**	1972	EQ	Pioneering contributions to general economic equilibrium theory and welfare theory
7) Wassily Leontief	1973	MAC	Development of the input-output method and for its application to important economic problems, i.a. to complicated inter-industry transactions in an economy
8) Gunnar Myrdal 9) **Friedrich von Hayek**	1974	MAC	Pioneering work in the theory of money and economic fluctuations, and analysis of the interdependence of economic, social and institutional phenomena
10) Leonid Kantorovich 11) Tjalling C. Koopmans	1975	RES	Contributions to the theory of optimum allocation of resources (contributions to analysis of consumption and money history and theory, including observations on complexity of stabilisation policy)
12) **Milton Friedman**	1976	MAC	Achievements in the fields of consumption analysis, monetary history and theory and demonstration of complexity of stabilisation policy
13) Bertil Ohlin 14) James Meade	1977	INT	Path-breaking contribution to the theory of international trade and international capital movements, analysis of effects of economic policy on foreign trade theory
15) **Herbert Simon**	1978	MAN	Pioneering research into the decision-making process within economic organisations
16) Theodore Schultz 17) Arthur Lewis	1979	WEA	Pioneering research into economic development research with particular consideration of the problems of developing countries

table 1 cont.

1	*2*	*3*	*4*
18) **Lawrence Klein**	1980	EC	Creation of econometric models and the application to the analysis of economic fluctuations and economic policies
19) James Tobin	1981	MAC	Analysis of financial markets and their relations to expenditure decisions, employment, production and prices
20) George Stigler	1982	MAC	Seminal studies of industrial structures, functioning of markets and causes and effects of public regulation
21) Gérard Debreu	1983	EQ	Incorporating new analytical methods into economic theory and rigorous reformulation of the theory of general equilibrium
22) Richard Stone	1984	MAC	Research into systems of national accounts
23) **Franco Modigliani**	1985	MAC	Pioneering analyses of saving and of financial markets
24) **James M. Buchanan Jr.**	1986	FIN	Contributions to the theory of economic and political decision-making
25) Robert M. Solow	1987	GRO	Contributions to the theory of economic growth
26) **Maurice Allais**	1988	EQ	Pioneering contributions to the theory of markets and efficient utilisation of resources in partial and general market equilibrium theory
27) Trygve Haavelmo	1989	EC	Pioneering contributions to development of econometric, i.e. methods applied to estimate and test quantitative aspects of economic relations
28) **Harry Markowitz** 29) **Merton Miller** 30) **William Sharpe**	1990	FIN	Pioneering work in the theory of financial economics, mostly in the area of company finances, including contribution to constructing a general theory of financial asset valuation and theory of portfolio management
31) **Ronald Coase**	1991	INS	Discovery and clarification of the significance of transaction costs and property rights for the institutional structure and functioning of the economy
32) **Gary S. Becker**	1992	BEH	Extending microeconomic analysis to a wide range of human behaviour and interaction, including non-market behaviour
33) Robert Fogel 34) Douglass North	1993	GRO	Renewing research in economic history by applying economic theory and quantitative methods in order to explain economic and institutional change
35) **Reinhard Selten** 36) **John Nash Jr.** 37) **John Harsanyi**	1994	GT	Pioneering analysis of equilibria in the theory of non-cooperative games
38) **Robert Lucas Jr.**	1995	MAC	Developed and applied the hypothesis of rational expectations in macroeconomic analysis
39) James A. Mirrlees 40) William Vickrey	1996	INF	Fundamental contributions to the economic theory of incentives under partial or asymmetric information
41) **Robert Merton** 42) **Myron Scholes**	1997	FIN	Developing a new method to determine the value of derivatives
43) Amartya Sen	1998	WEA	Research on fundamental problems in welfare economics concerning social choice, welfare measurement, and poverty
44) Robert A. Mundell	1999	INT	Analysis of monetary and fiscal policy under different exchange rate regimes and analysis of optimum currency areas

table 1 cont.

1	*2*	*3*	*4*
45) James J. Heckman	2000	EC	Development of theory and methods for analysing selective samples
46) Daniel L. McFadden			Development of theory and methods for analysing discrete choice
47) **George A. Akerlof** 48) **A. Michael Spence** 49) **Joseph E. Stiglitz**	2001	INF	Analyses of markets with asymmetric information
50) **Daniel Kahneman**	2002	BEH	Integrated insights from psychological research into economic science, especially concerning human judgement and decision-making under uncertainty
51) **Vernon L. Smith**			Establishing laboratory experiments as a tool in empirical economic analysis, especially in the study of alternative market mechanisms
52) Robert F. Engle III	2003	EC	Methods of analysing economic time series with time-varying volatility (ARCH)
53) Clive W. J. Granger			Methods of analysing economic time series with common trends (cointegration)
54) Finn E. Kydland 55) Edward C. Prescott	2004	MAC	Contributions to dynamic macroeconomics: the time consistency of economic policy and the driving forces behind business cycles
56) **Robert J. Aumann** 57) **Thomas C. Schelling**	2005	GT	Enhancing understanding of conflict and cooperation through game-theory
58) Edmund S. Phelps	2006	MAC	Analysis of intertemporal trade-offs in macroeconomic policy
59) **Leonid Hurwicz** 60) **Eric S. Maskin** 61) **Roger B. Myerson**	2007	MIC	Foundations of mechanism design theory
62) **Paul Krugman**	2008	INT	Analysis of trade patterns and location of economic activity (international trade and economic geography)
63) **Elinor Ostrom**	2009	MAN	Analysis of economic order, especially common good
64) **Oliver E. Williamson**			Analysis of economic management especially the boundaries of the firm
65) Peter Diamond 66) Dale Mortensen 67) Christopher Pissarides	2010	MIC	Analysis of markets with search frictions
68) Thomas Sargent 69) Christopher Sims	2011	MAC	Empirical research on cause and effect in the macroeconomic
70) Alvin E. Roth 71) Lloyd S. Shapley	2012	GT	Theory of stable allocations and the practice of market design
72) Robert J. Shiller 73) Eugene F. Fama 74) Lars Peter Hansen	2013	FIN	Empirical analysis of asset prices

table 1 cont.

1	*2*	*3*	*4*
75) Jean Tirole	2014	MIC	Analysis of market power and regulation
76) Angus Deaton	2015	MIC	Analysis of consumption, poverty, and welfare
77) **Oliver Hart** 78) **Bengt Holmström**	2016	INS	Contributions to contract theory
79) **Richard Thaler**	2017	BEH	Contributions to behavioural economics
80) **Paul Romer** 81) **William Nordhaus**	2018	MAC	Empirical studies on technological innovations and climate change in macroeconomic analysis

Note:
* D/S stands for discipline or subdiscipline of economic sciences to which the awarded achievement belongs:
MIC – microeconomics MAC – macroeconomics
MAN – management GRO – theory of economic growth and economic history
FIN – financial economics EQ – general and partial economic equilibrium theory
BEH – behavioural economics GT – game theory
INF – information economics INT – international economics
INS – institutional economics WEA – economics of wealth and development
EC – econometrics RES – theory of optimum allocation of resources
Names in bold highlight the scientists studying uncertainty or risk (presented in detail in the later part of the paper).

Source: Based on: The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel, 1969-2018 (2019).

4.2. Uncertainty and risk in econometrics

Econometricians, whose achievements were recognised with the Nobel Prize in Economic Sciences, reflected on the role of risk in processes modelling economic phenomena. It is most evident in the research of Lawrence Klein. He focused, among others, on liquidity risk, credit risk and mostly exchange rate risk. The researcher argued that it is most adequate to measure the exchange rate risk as divergence between exchange rate forecast and its actual value (consequently, exchange rate risk can be gradually reduced by improving forecasting methods) (Herring, 1983; Morris & Shin, 2016). In modern scientific research, there are also research threads related to econometric risk recognition and econometric methodology needed for quantitative risk assessment of various categories, facilitating management processes of these risks (Gourieroux & Jasiak, 2007).

4.3. Uncertainty and risk in macroeconomics

Insecurity and risk in macroeconomics were introduced, i.a. by Modigliani and Lucas Jr. Franco Modigliani together with Merton Miller, a prominent researcher and a Nobel Prize winner in finance, developed a claim regarding the impact of capital structure and investment decisions on enterprise valuation and

ability to generate profit under conditions of free competition. One of the assumptions of the developed model is closely related to business risk and presumes that the risk of entities can be measured with the help of standard deviation of expected earnings before deducting interest and taxes. Therefore, entities of identical level of standard deviation belong to the same risk class (Czekaj & Dresler, 1995). What is more, Modigliani co-authored also research on consumption decisions under insecure conditions (Drèze & Modigliani, 1972).

In his studies, Robert Lucas Jr. dealt with insecurity further developing foundations of rational expectations theory of John Muth. Lucas also analysed research achievements of two other Nobelists, Friedman and Phelps, who studied dependencies between inflation and unemployment. He observed that only insecure and unexpected by the society changes in money supply can viably impact changes in unemployment level. In his works, among others in *Expectations and the neutrality of money* (1972), Lucas emphasised that monetary policy efficiency in fighting unemployment is determined by its unpredictability.

Additionally, Friedrich von Hayek, a prominent representative of Austrian school, referred in his analyses on decision-making theories to insecurities of the surrounding world. According to him, insecurity signifies a situation where each individual decision maker has only a part of the information they need. It is only the whole body of required knowledge (held by aggregated set of all decision makers in a specific decision process) that can eliminate existing uncertainty. Hayek also believed that only the market, as a mechanism for coordinating information exchange, can deal with uncertainty and resulting from it dispersed knowledge (Brady, 2011; von Hayek, 1945).

Nobel Prize Laureates from 2018 also contributed to studies in insecurity and risk in macroeconomics. William Nordhaus with his research on impact of environmental risk on economic conditions and Paul Romer by substantially contributing to explaining dependencies between economic growth and dynamic growth of innovations inherently linked with risk.

4.4. Uncertainty and risk in microeconomics

In microeconomics, regard to insecurity and risk can be noted in Leonid Hurwicz's research. He created one of the optimisation criteria used in forecasting economic phenomena mostly of unmeasurable nature. Hurwicz's criterion applies to making decisions under insecure conditions and forms a kind of compromise between optimistic and pessimistic approaches demanding to choose the

option with the highest maximum usefulness of the result (earnings). This criterion is also called Hurwicz's pessimism-optimism index (Gaspars-Wieloch, 2014). Co-awarded Eric Maskin contributed to risk research. He carried out studies in this area together with John Riley. They tackled auctioning, in particular risk accompanying it resulting, above all, from insecurity as to buying preferences of the bidders (Maskin & Riley, 1984). Maskin used in his studies observations regarding auctioning conditions, among others, authored by the third Nobel Prize Laureate in Economic Sciences from 2007 – Roger Myerson (1981) studying both possibilities to optimise seller's risk and risk neutral position of the buyer. The significance of the role of uncertainty and risk is also currently analysed in microeconomics, where research based on contributions of Nobel Prize Laureates is continued, concerning, for example, economic decision-making under risk conditions (Kirchler et al., 2017).

4.5. Uncertainty and risk in management theory

Management science researchers played a particular role in scientific approach to insecurity and risk. One of them was Herbert Simon who studied insecurity and its impact on decision processes in organisations. He developed, i.a. a rational decision-making model and a concept of limited rationality with which he greatly contributed to the change in perception of the concept of rationality of human actions related to existing insecurity. Results of his work connected to insecurity and risk can be noticed, among others, in *Administrative behavior: A study of decision making processes in administrative organization* (1965), *Models of discovery and topics in the methods of science* (1977). His works are synthesised in a new theory for organising decision-making.

The role of risk in management was also tackled by Oliver E. Williamson and Elinor Ostrom. Williamson (2002) developed theory of transactional costs, institutional economics and analysed secure and insecure choices of business entities, their rationality, investment risk, opportunistic behaviour risk, as well as risk resulting from information asymmetry.

In turn, Elinor Ostrom, the first woman to be awarded with the Nobel Prize in Economic Sciences, contributed to identifying a new economic stream – economy of the common good. Ostrom (1990) complied a catalogue of principles for community management (without interference of governments or privatisation) where she assumes, among others, risk of unexpected, critical situations and necessity to have low-cost and efficient mechanisms for solving problems, both those unexpected and probable ones.

In addition to the research achievements of Nobel Prize winners, risk and uncertainty now are undoubtedly important research areas in both the theory of management sciences and the practice of organisations management (Aven, 2016).

4.6. Uncertainty and risk in economic equilibrium theory

Insecurity and risk also became the subject of research in the economic equilibrium theory. They were most emphasised in the works of Kenneth J. Arrow, including the above mentioned *Essays in the theory of risk bearing* (1979). Arrow also carried out studies in information asymmetry thus contributing to development of insurance economics dealing with, among others, the issue of risk in analysis of moral hazard (Arrow, 1979).

John R. Hicks, who received the Nobel Prize in 1972 together with Arrow, as well addressed the issue of risk in his numerous scientific studies. In his works, i.a. *Value and capital: An inquiry into some fundamental principles of economic theory* (1939), he dealt with economic risk proving, among others, that risk can be insured by adopting unfailing functioning of the law of large numbers.

Paul Samuelson (1952) in turn contributed to risk research with his input in development of expected utility theory.

Maurice Allais, the author of the Allais paradox, undermining expected utility theory with respect to proving existence of choices non-compliant with axiom of independence, used risk as a determinant of methodology implemented in the experiment. The method used in the experiment was to study dependency between secure and risky choices in the decision theory. In his works, among others, *The role of capital in economic development. In the econometric approach to development planning* (1965), Allais, apart from macroeconomic issues, focused on the causes and risk of occurrence of economic crises.

The issue of uncertainty and its role in economic equilibrium theory is continued in contemporary scientific research (e.g. Chichilnisky, 2010).

4.7. Uncertainty and risk in financial economics

The broadest circle of laureates undertaking in their research the subject of insecurity and risk are scientists awarded for their achievements in financial economics. Markowitz, Miller and Sharpe, receiving jointly the Nobel Prize in 1990, were recognised for innovative works in economic finance theory and

business financing, including contribution to developing a general theory of valuation of financial assets, proving existence of risk-free financial assets and for contribution in theory of investment risk.

Harry Markowitz developed the so-called *portfolio theory* concerning financial investment optimisation. In this field, he studied impact of assets risk, their correlation and diversification in relation to probable investment portfolio return. Thus, he advanced the theory key to managers, i.e. optimal investment theory concerning assets varying in expected return rate and risk. Results of his path-breaking research are included, among others, in *Portfolio selection* (Markowitz, 1952). Whereas Merton Miller developed economic methods for reducing business risk. While William Sharpe made a major contribution to theory of shaping financial assets prices by co-authoring Capital Asset Pricing Model (CAPM) based on Markowitz's theory, conducing economic equilibrium theory under risk circumstances (Varian, 1993). Results of his considerations Sharpe published inter alia in *Capital assets prices: A theory of market equilibrium under conditions of risk* (1964).

Whereas Robert Merton's research supported creation of financial instruments and facilitated more efficient risk management in financial markets. Myron Scholes in turn authored new financial instruments encumbered with lesser risk, contributing also to facilitating the risk management process.

Output of James M. Buchanan Jr does not remain indifferent when it comes to the studies on insecurities and risk, however, it serves in a totally different context. Buchanan carried out research aimed at designing a system of governance which would ensure balance between coercion necessary to protect the citizens against external threats and insecurity and risk of the coercive force being used by special interest groups.

Research on the importance of uncertainty and risk in the field of financial economics can also be observed currently in many scientific studies, for example, concerning the role of risk in functioning of financial markets (Rigotti & Shannon, 2005).

4.8. Uncertainty and risk in behavioural economics

Behavioural economics representing psychological and sociological approach to economic studies also has its recognised with the Nobel Prize representatives who in their research included risk as a determinant of market behaviour. Daniel Kahneman and Vernon L. Smith were awarded with the Nobel Prize

for innovative research into decision-making under uncertainty and substantial insights from psychological research into economic science. Kahneman applied conclusions from cognitive psychology to economic analysis, in particular with respect to individual's behaviours in uncertainty, thus laying the groundwork for a new research area – economic psychology. Whereas Smith developed methods of laboratory experiments in economics which furthered path-breaking understanding of economic behaviours under uncertainty and risk. Gary Becker, a Nobel Prize winning researcher of behavioural economics, also co-authored studies on conditioning of insurance of marketable risks (Ehrlich & Becker, 1972).

Also 2017 Laureate Richard H. Thaler studies behavioural economics. In his works he explores, among others, *Misbehaving: The making of behavioral economics* (2015), studies the impact of thinking and emotions (including cognitive biases) on economic decisions of individuals under risk conditions and on operation of markets.

4.9. Uncertainty and risk in game theory and information economics

Another area of risk and insecurity research is game theory directly linked to risk and rationality of making optimal decisions in various situations. John F. Nash Jr., Reinhard Selten and John C. Harsanyi made a pioneering discovery concerning analysis of equilibrium in game theory, including making decisions under risk conditions. Nash developed a concept of equilibrium for non-cooperative games *Equilibrium Points in N-person Games* (1950) later to be called Nash equilibrium. Reinhard Selten (1999) was the first to improve the concept of Nash equilibrium to analysis of dynamic strategic interaction. He applied this concept to competition analysis. While John Harsanyi analysed game theory under risk conditions and incomplete information providing thus theoretical foundation for a new research field – information economics. He published his considerations in *Games with incomplete information played by bayesian players*. Part I, II, III (1967). Further eminent achievements of the Nobel Prize Laureates are connected with information economics. In this discipline, research in the area of risk was carried out, among others, by George A. Akerlof, A. Michael Spence and Joseph E. Stiglitz. All three researchers attempted to find the answer to the question how information asymmetry impacts risk of failure in relations between market participants and macro- and microeconomic phenomena (Lofgren, Persson, & Weibull, 2002).

Furthermore, Thomas C. Schelling (1981) dealt with the issue of insecurity of economic phenomena. He focused on methods for solving interstate conflicts in order to prevent an armed conflict. He analysed certain and uncertain determinants of retaliation and resistance against adversary, together with their credibility and effectiveness.

Issues directly related to the role of risk and uncertainty in game theory and information economics are currently most often associated with the determinants of making choices under uncertainty and risk, becoming the subject of interest for many modern researchers (e.g. Reneke, 2009).

4.10. Uncertainty and risk in international economics

Paul Krugman – scientist awarded with the Nobel Prize for his contribution to international economics – in his studies centred around geographical and economic aspects of trade, observing world markets and the shape of globalisation processes, analysed the risk of occurrence of economic crises and recession, as well as their impact on management processes and shape of market relations. Apart from risk, Krugman (Krugman, Obstfeld, & Melitz, 2018) also focuses on the issues of market information economics and uncertainty resulting from them.

The importance of uncertainty and risk in the context of international economics research is currently analysed in the context of the risk arising from globalization processes and the uncertainty of international economic and financial policy (Das, Kannadhasan, & Bhattacharyya, 2019).

4.11. Uncertainty and risk in institutional economics

Institutional economics also forms a background area for research related to business risk. In this respect Ronald Coase, Oliver Hart and Bengt Holström furthered development of this research. Coase (1937), pioneering in the transactional costs theory (*The Nature of the Firm*), formed a claim with regard to property which later was adopted to economic contract theory, where an ideal contract is interpreted as an agreement in which risk was evenly spread between the parties, and all information was transferred (lack of asymmetry).

Oliver Hart in his studies also contributing to development of contract theory analysed the risk of incomplete agreements, forming theories of different versions of contracts. Thus, the created theory of incomplete contracts published

in *Foundations of incomplete contracts* (Hart & Moore, 1998) took into account insecurity related to concluded agreements resulting from the lack of possibility to foresee all potential variants of provisions. Hart's research findings were applied in business management and institution design.

Whereas Bengt Holmström believed that contracts in themselves substantially protect against uncertainty thus positively impacting safety of forming economic and social relations. Furthermore, when developing his contract theories, he took into consideration uncertainty which accompanies having a contract drawn up by a subcontractor resulting from the lack of possibilities for ongoing monitoring activities of the other party concluding the agreement as well as ways to restrict them in order to create a contract optimal to the highest degree possible (Schmidt, 2017).

On the basis of the above-mentioned Nobel Prize-winning studies, modern scientific research is carried out related to the analysis of behaviour in conditions of uncertainty according to the new institutional economics (Dequech, 2006).

5. Discussion

The above presented research findings allowed to identify the issue of uncertainty and risk in research of the Nobel Prize Laureates in Economic Sciences; therefore, the main aim of the present paper has been achieved. What is more, answers to all research questions have been obtained, namely:

- Research on insecurity and risk is carried out in many disciplines and subdisciplines of economic sciences, e.g. econometrics, macro- and microeconomics, management, general equilibrium theory, financial economics, behavioural economics, game theory, information economics, international economics, institutional economics.
- Among the Nobel Prize Laureates in Economic Sciences there can be identified a numerous group of researchers addressing in their considerations the issue of uncertainty and risk.
- The researchers selected from the range of Nobel Prize winners made significant contribution to increasing awareness of the importance of uncertainty and risk in many areas of operation of entities, businesses and national economies which was proven in many scientific research projects and publications.

The achievements of Nobel Prize winners in the area of risk and uncertainty presented in this paper have also become an inspiration for their continuation within the different sub-disciplines of economic sciences in numerous contemporary scientific publications, the subjects of which was outlined in the summary of research analysis in each sub-discipline.

6. Conclusions

The main contribution of this research is to fill the research gap identified in the literature related to the lack of extracting scientific research concerning the role of uncertainty and risk in many dimensions of economic and social life from the achievements of Nobel Prize Laureates in Economic Sciences. The systematisation of these issues in the form of one scientific text constitutes the added value of this work.

From the perspective of organisation management practice, the strongest inspiration for further research was the research contribution of Nobel Prize winners in the field of management, namely: Herbert Simon, Oliver Williamson and Elinor Ostrom. Their achievements regarding decision-making determinants, analysis of factors affecting their rationality or the causes and effects of choices made in conditions of uncertainty and risk have found a strong grounding in the theory and practice of risk management in business entities, regardless of the size or profile of activity.

Research limitations result from, among others, the adopted narrowed research area – achievements regarding the role of uncertainty and risk in economics only in the research of the Nobel Prize winners. Future studies should therefore extend the scope to include also achievements of researchers outside of the Nobel Prize Laureates. Continuation of the research on the role of uncertainty and risk in economic sciences is also necessary due to the observed high dynamic of social and economic changes resulting from globalisation and internationalisation processes and impact of these changes on management processes in contemporary organisations. In this perspective, future research should therefore focus primarily on the importance of uncertainty and risk in microeconomics, macroeconomics, international economics, and management theory and practice. In the latter area, providing organisations with practical guidance concerning the processes of risk identification of their activities, methods of its assessment, analysis, control and prevention of the negative effects of risk factors materialisation.

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