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Black swan: Synthesis and Future Research Directions

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TABLE OF CONTENTS

LIST OF TABLES AND FIGURES	3
ABSTRACT	5
1. INTRODUCTION	7
<i>1.1 Research problem and justification</i>	9
<i>1.2 Purpose of the study</i>	10
<i>1.3 Delimitation and structure of the study</i>	10
2. METHODOLOGY	12
3. DEVELOPMENT OF THE CONCEPTUAL FRAMEWORK	16
<i>3.1 Theoretical context</i>	16
<i>3.2 Black swan's effect</i>	17
<i>3.3 Protection against black swans</i>	17
4. REVIEW OF THE LITERATURE	36
<i>4.1 Studies related to theoretical aspects</i>	36
<i>4.2 Black swans' effects</i>	40
4.2.1 Basics of black swan's effect	40
4.2.2 How black swan affects systems	41
<i>4.3 Foreseeing black swans</i>	43
4.3.1 Preparing to unnoticeable black swans	44
4.3.2 Tools and methods to foresee black swans to prevent them	45
4.3.2 Foreseeing and preventing nature's black swans	48
<i>4.4 Overall evaluation</i>	50
5. CONCLUSIONS AND LIMITATIONS	54
<i>5.1 Contribution</i>	54
<i>5.2 Managerial implications</i>	54
<i>5.3 Future research opportunities</i>	55
<i>5.4 Limitations</i>	57
REFERENCES	58

LIST OF TABLES AND FIGURES

	Page
Table 1: Search Results from the Databases	14
Table 2: Studies and Key Findings	19
Figure 1: Flowchart of the extracted literature	15
Figure 2: Findings categorized by aspects	51

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ABSTRACT

This literature review attempts to synthesize existing research of black swan phenomenon. Using a systematic methodology, a total of 66 key articles are identified as relevant. A framework is developed for black swans, which studies theoretical aspects of black swans, black swans' effects and protection against black swans. The results show that there are only few black swan related studies and main focus should be creating a common theoretical ground work for black swan concept which should lead to more efficient prevention and protection studies, which is most vital study direction regarding black swans. The results also suggest that black swans work in complex and systematic manner and the effects can spread to other systems directly or indirectly. Study also highlights possible teleological aspects of black swan events. The study also notices that prior black swan related research which is not connected to current black swan research should be actively collected and added to current black swan research to eliminate potential unnecessary research. The thesis concludes by offering some theoretical and managerial implications.

KEYWORDS: Black swan, Nassim Taleb, HILP, Emerging Risk, Risk Assessment, Literature Review

1. INTRODUCTION

People have always had looked for ways to anticipate the future. The process of registering changes in the environment and using them to understand a causality chain that would reveal the next event is one of the basic function of human brain. It has been one of the humankind's evolutionary advantage comparing to other animals. People use foresight for their own benefit. In early days, it helped people to survive where it now mostly prepares us to upcoming changes which happens now a day more frequently but ordinarily do not have same kind of "do or die" mentality than in the past.

From people, foresighting has spread everywhere and in the modern society, there probably are not many capable organizations that do not use foresighting at least at some level to gain advantage. Even though our brain is almost design to foresee future events and we have created systems which single purpose is to forecasting what happens in the future, we are often, if not most times, really bad at it. When forecast goes wrong and is followed by a minor event, outcomes are also minor. But when the event is major or extreme, outcomes can be devastating. Especially since, the outcome can start a chain reaction which affects far in the future. What is even worse, the event itself, like 9/11 attacks, might seem like a predictable event and afterwards they might look preventable.

Nassim Taleb examines rare and extreme events in his book, *The Black Swan: The Impact of the Highly Improbable*, and gives his own explanation concerning why people do fail to foresee major events which have broad consequences even thought at hindsight they make almost perfect sense. Taleb calls these events as black swans. Taleb's book's first edition was released in 2007 and got its boost from the 2007-2008 financial crash. Even though, *The Black Swan: The Impact of the Highly Improbable* is, according to its author, more philosophical opus than a scientific script, it still draws the attention of academic world. Taleb construct his book in a way where he first introduces his own world view and simultaneously explains what is a black swan.

Taleb's bestseller has gotten influences from several thinkers, from mathematicians and philosophers to economists and all the way to his grandfather's chauffer (Taleb 2013: 45, 92). Taleb is not trying to take the credit of the concept of black swans to himself, and admits the topic have been in a conceptual discourse way back 1800's (Follain 2013). But it's unquestionable fact that Taleb has brought them to the knowledge of the great masses. He even named his book after Karl Popper's metaphor of black swan, which views human incapability to believe certain thing before they are proved, in this context meaning actual

black swans that were discovered in Australia in (Bogle 2008). Black swan is also heavily related Frank Knight's epistemological concept of uncertainty (Davidson 2010).

To understand black swan phenomena, we must understand the world the same way as Nassim Taleb sees it. One of the first things we can see from Taleb's work is his strong disbelief of determinism. He praises Henri Poincaré and makes sure that he is known as an early discoverer of chaos mechanics before Edward Lorenz (Taleb 2013:223). He also notes how the world is dynamic (Taleb 2013:226). These examples of complex systems basically denounce the Newtonian world view in Taleb's mind. The world is chaotic, nonlinear and dynamic. (Taleb 2013:126). Taleb believes that there is no destiny and all events are caused by a random chance. He offers several black swan events which were caused by random factors, like how the Titanic sank or Fleming discovering penicillin. By this, Taleb points out how important inventions are sometimes caused by accident (Taleb 2013:214), accepting the possibility of a random event could be described as a cornerstone to the black swan concept.

Taleb defines a Black Swan as a highly improbable event with three characteristics: It's totally unpredictable, its impact is massive and it's amenable to explanation, after it has happened. (Heinonen and Ruotsalainen 2013:304). Meaning that in retrospective a black swan seems predictable, not random (Sniedovich 2012). The author explains that we are good at predicting the ordinary, but not good at predicting the irregular and that big events, while opportunities are almost always irregular or eccentric (Dollinger 2008). He has questioned the ability of people in general as well as of policymakers and regulators to seek appropriate protection from a category of events that they consistently overlook (Terzi 2010). Black Swan events cannot either be predicted from historical trends and they often surprise managers with discontinuities (Millett 2010). According to Taleb, there is no meaningful forecasting method due to a chaotic world where reality is shaped by rare black swans. (Werther 2013). He thinks Black Swans are unfair and damaging. *"He would like to eliminate many of them, or at least diminish their impact. But he stresses that the world today is dominated by the unknown and improbable, and promises that the future will be even less predictable"* (Dollinger 2008: 354).

To be more precise, Taleb offers five reasons why people are unable to see black swans before they happen. First, due to a confirmation bias we concentrate our attention to possibilities which are previously discovered and are general. Second, a narrative perception where people improperly interpret observations due to unintentional biases. Third, people act like there are no black swans because human nature was not

“programmed” to detect them. Four, some black swans do not leave any evidence, due to lack of them the probability of black swans are misjudged. Five, people concentrate to well-defined sources of uncertainty and concentrate list of black swans which have already happened while missing upcoming swans which are harder to discover (Taleb 2013:84).

Taleb’s key message, in his book, is that forecasting is rarely possible. Forecasting is based on historic data, and developed through a mindset shaped by experience that often is prejudice, because human nature seeks certainty and reassurance (Lloyd 2008). Instead of preventing them, Taleb suggest, planning our actions so their impact can be minimized. He offers 10 metaphoric principles, for building systems that are robust to black swan events: “1. *What is fragile should break early while it is still small. Nothing should ever become too big to fail.* 2. *No socialization of losses and privatization of gains.* 3. *People who were driving a school bus blindfolded (and crashed it) should never be given a new bus.* 4. *Do not let someone making an “incentive” bonus manage a nuclear plant – or your financial risks.* 5. *Counterbalance complexity with simplicity.* 6. *Do not give children sticks of dynamite, even if they come with a warning.* 7. *Only Ponzi schemes should depend on confidence. Governments should never need to ‘restore confidence.’* 8. *Do not give an addict more drugs if he has withdrawal pains.* 9. *Citizens should not depend on financial assets or fallible “expert” advice for their retirement.* 10. *Make an omelette with the broken eggs.*” (Sniedovich 2012). Taleb’s intentions to stop using resources to identifying black swan for preventing them and start concentrating to minimize their effects can be seen more clearly in a 2012 interview where he told, “*My whole idea of the black swan is to stop looking for black swans and analyze the fragility and robustness of systems*” (Milner 2017).

1.1 Research problem and justification

This thesis will study extreme and rare events, which are difficult to foresee. The main purpose is to collect and synthesize the core literature of such events. It will be done by setting Nassim Taleb’s black swan as a benchmark concept. Black swan is chosen to be the corner concept of this thesis since it’s currently one of the most well-known and popular concept which examines extreme and rare event which are difficult to foresee. Even though black swan and other similar concepts are known at least at name level by the great masses, the gap between popular level knowledge and theoretical level understanding is often major. Understanding black swans and the possibility of rapidly

changing environment should help every organization to prepare for the future. Outside of the gap between common understanding and understanding the mechanics causing black swans, topic's literature is also fragmented and there are no practical guidelines which literature should be included to the topic and which should be excluded from it. Collecting and synthesizing major themes and different concepts under one study will help to understand the phenomena and help the future research of the topic.

1.2 Purpose of the study

The study presented in this thesis is conducted as a systematic and critical literature review. The purpose of this study is to synthesize current literature on black swans in relevant parts and analyze how it is received. This will be done by identifying, selecting, reading, and summarizing 66 key articles published in scientific journals. Following this, an integrative framework is created which demonstrates how black swans theoretical concept is seen at the field, how black swan's effect affect afterwards, and is it possible for organization to protect itself against black swan. This thesis contributes to the development of the black swan literature by examining current black swan research to synthesize chosen themes of literature and expanding the black swan definition by recognize similar concepts which are currently left, as whole or partially, outside side of the black swan.

1.3 Delimitation and structure of the study

This study include following delimitations. The study will be limited primarily to black swans and related concepts in economics, management and related fields, meaning black swan phenomenon which do not affect in these fields will be delimited outside of this literature review. This will be done mainly by limiting search terms to economics related searches in chosen databases. Findings which do pass the limitations but do not meet the previous requirements will be concluded to the study to ensure the repeatability of this study. Terms similar to black swans which do have limited results will be searched without previously mentioned economics related criteria. This is done to be sure that any potential findings will not be left outside of the study due too strict limitation regarding samples. The study will also be limited to first extraction, meaning later identified concepts, which are similar to black swans will not lead additional searches in this study but do offer a better starting point for future studies.

Study's structure is as follows. First, the methodology of the search is presented which shows how the relevant literature was identified. Next, the literature is reviewed to identify significant themes in it. Next, a framework is designed and based on most important themes and explained. Following this, the framework is used to describe previous literature and attempts are made to synthesize extant research. This helps to explore existing findings and provides a good starting point for focusing future research efforts, which is the topic of the next chapter. Finally, the article concludes by offering both theoretical and managerial implications.

2. METHODOLOGY

Building a systematic review on black swan turned out to be a challenging process due to a relatively fresh concept of the black swan. Taleb's book is quite recent and, even though it has produced considerably conversation in last ten years, it still has relatively little actual material for a systematic review. Another challenge rose from finding material which is similar to Taleb's black swan concept, but which does not use black swan label. This material includes publications that appeared before Taleb's book and material which just for some other reason does not use black swan label.

To identify the focal literature outside black swan concept, the Taleb's book itself was read to set the limitations for searches. According to Taleb, black swans have three distinguishing characteristics. First the event is unfamiliar sighting because it's outside of the regular expectations. Second, it will have extreme impact. Third, after the event has happened people start to be reasoning why and how the event happened to make it explainable and predictable. (Taleb 2013:16). In another word, a black swan event has low probability, high impact and cannot be noticed before it happens.

Using black swan's description, *HILP-events* was recognized as a one of similar concept for black swan. HILP-events are high impact low probability events (Paltneri and Renier 2017). Besides HILP, also same meaning terms "*high impact low probability*" and "*low probability high impact*" was added to the search list. Outside HILP-events, there was not recognized any other concepts which were closely related to black swan events at this point, so it was decided that the rest of data was going to be searched by hand, using topics which were heavily related to main points of black swan.

Terms "black swan*", "HILP", "high impact low probability", "low probability high impact", "risk assessment" and "emerging risk" was chosen to be the search terms. Scopus and Web of Science were chosen as the databases for the search. "*Risk assessment*" and "*emerging risks*" were chosen as search topics due to black swan's heavy links to unpredictability and extreme outcomes. Common terms "risk assessment" and "emerging risk", did produce excessive amount of hits, due to this reason, a second layer term "management" was added to narrow down findings with "risk assessment" and "emerging risk" terms. Terms "black swan*", "risk assessment" and "emerging risk" was chosen to be searched including categories *business*, *management* and *economics* in Web of Knowledge –database and including categories *Busi* and *Econ* in Scopus-database. Due to a relatively low number of finding with terms "*hilp*", "*high impact low probability*"

and “*low probability high impact*” there was no need for additional filter for them. The search when the literature was extracted was done in September 2017.

The screening of the material was decided to do in four phases. First, all the selected terms were searched with possible topic or inclusion filters. The purpose of the first phase was to gather all of the articles together which included at least one of the aforementioned key words. None of the articles was not excluded in first phase. At the second phase, all articles were screened by their name and articles which heavily implied not to be related to the topic were removed. Articles which were at least partially related or could not be identified by title were included to next screening. There were massive amount of accounting related articles which did not fit for the limitations and were discarded at the second screening. These articles were found under search terms “risk assessment” or “emerging risk”. In hindsight, excluding topics like “accounting” would have speed up the screening process significantly but at least used method did not compromise the quality of the extracted literature. There were also handful of “HILP” related articles which were excluded due their “HILP” did not refer to “high impact low probability” but to a medical term “Hyperthermic Isolation Limp Perfusion”. The duplicates were also removed at the second screening. In a third screening, articles’ abstract were read and again unfit articles were excluded. Often the deciding factor was, what kind of risks did the article studied. If the studied risk was outside of black swan’s definition the article was rejected. If the type risk was not specified in the abstract, the article was included to the last phase of screening. At the time, “risk assessment” and “emerging risk” related articles were the majority and most of them were unfit for the systematic review, so special attention was paid to recognize unfit articles under those search terms to reduce the number of articles to be read. In the fourth screening, all of remaining articles were read completely and either was rejected or accepted to the systematic review.

Table 1: Search Results from the Databases

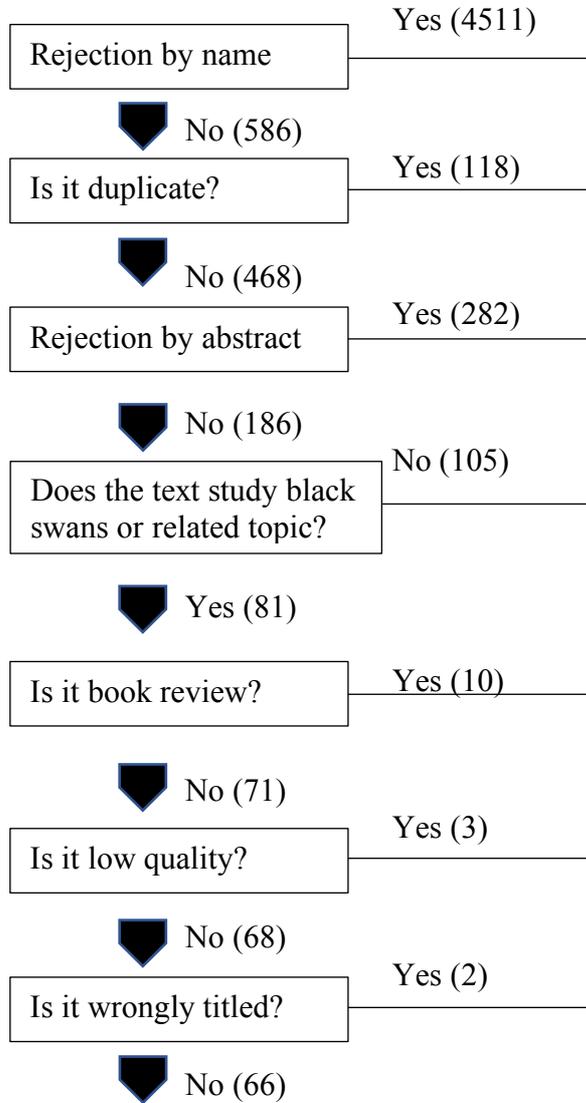
Database	Step	# Left
Web of Science	Initial search	601
	After exclusion by title	195
	After exclusion by abstract	40
Scopus	Initial search	4496
	After exclusion by title	391
	After exclusion by abstract	146
Combined articles	Selected to be read	186
	Accepted to systematic review	66

In the initial search, the large number of the findings can be explained by the excessive quantity of findings of “*risk assessment*” and “*emerging risk*” related hits which were not connected to black swans in anyway. Another noteworthy observation is the amount of the articles which were rejected after reading. Most of them were initially found by search term “*risk assessment*” or “*emerging risk*” and could not be rejected without reading the article. Ten articles which were rejected after the reading were book reviews, three were rejected due a low quality and two articles were rejected because black swans were incorrectly mentioned in the title but the article itself did not dealt with the subject of black swans.

Figure 1: Flowchart of the extracted literature

Articles found from initial search

5097



**Final sample
66 articles**

**Excluded articles
5031**

3. DEVELOPMENT OF THE CONCEPTUAL FRAMEWORK

The material was first read to identify possible themes for the framework itself. The goal was to find two or three themes which would offer a pragmatic view for the systematic review. After the material was read, there was identified three suitable subjects for further reviewing: Theoretical aspects (A), effects (B) and protection against black swans (C).

After identifying of the relevant studies, all included articles were read and information on the type of research, sample size, sample characteristics, connections and key findings were extracted. Doing so, special attention was paid to how the studies connected to each other which was an essential step to synthesize black swan literature by themes.

While chapter will briefly outline the different aspects of black swans that have been identified and how relevant studies have connected to each other's, the next chapter will explore these results more in depth.

3.1 Theoretical context

First topic which was identified from literature was the need for specific theoretical ground for black swan. During its relatively short existence, Taleb's concept has received a massive amount of attentions and it has faced both agreement and critique (e.g., Follain 2013; Millett 2010, Mueller and Stewart 2016; Werther 2013) but the deeper problem might be in the need for a scientific approach to the topic (e.g., Bogle 2008; Allington, McCombie and Pike 2017; Booth and Mazzawi 2008).

One interesting note from literature is how problematic is to categorize the book. Even though Taleb adds disclaimer that the book is philosophical opus, it is often viewed almost as a scientific research and so, its methods and outcomes are questioned. Some blame for this could be pointed toward Taleb's education and career. A person who has worked as a professor in several respected universities and is a stock broker is likely taken as more scientific minded person. Regardless the usefulness of arguing with a Taleb's philosophical view, it could be meaningful to examine the theory of black swan events and study, could it be applied to understand how the black swans work in a concrete world.

Taleb has expanded both his book and the black swan concept from the first edition and has tried to regard some critique in his second edition and these changes could be interesting aspect for closer view.

3.2 Black swan's effect

Another aspect which rose from literature was how black swans affect after they have happened. Due to Taleb's notes that black swans cannot be prevented, this is an important aspect to the systematic review.

There is large interest toward black swans in financial sector. Numbers of researches have tried to find out how black swans affect to market prices and are there any way to protect against them (e.g., Ajmi, El-montasser, Hammoudeh and Nguyen 2014; Almudhaf and AlKulaib 2017; Estrada 2009; Olson, Miller and Wohar 2012; Taylor and Williams 2009). Market point of view might not provide any findings related concrete world, but it's still part of literature and may provide useful financial aspects. Also, the effect toward consumer goods and supply chains has been studied (e.g., Olson and Wu 2013; Siomkos 1999). These studies are not directly connected to black swans, but their mechanics may offer useful aspect for later research.

Another aspect identified from effect has to be similarities between HILP-events and natural catastrophe black swans (e.g., Carsamer 2016; Chawla, Mangaliso, Knipes and Gauthier 2012; Knudsen 2010; Paltrinieri et al. 2017; Rheinberger and Treich 2017). These cases are not the black swans the great audience is used to see if compared to terrorist attack or financial crash black swans, but their affect can be similar (Olsen et al. 2013) and even Taleb himself have noticed their existent in his book (Taleb 2013: 282, 372), so they are inevitable part of black swan's concept.

3.3 Protection against black swans

Questioning can black swans be prevented is a useful question. According to Taleb, black swans cannot be prevented (Taleb 2013: 223, 264). The question divides opinion in the literature which makes it even more meaningful question for the systematic review. Scholars like Bogle (2008) shares Taleb's opinion where e.g. Follain (2013), Werther

(2013) sees it differently. In the literature, prevention question transforms to, can black swans be seen, which will decide should organizations to passively protect themselves against possible black swans or should they actively try to search them and maybe even try to prevent them.

Another useful point of view for this part will be additional methodologies which examines similar question like black swans. This part's intension is to bring up possible alternative tool which might be useful for finding black swans.

In sum, the research can be summarized by stating that there is a total of three groups of articles within the developed framework. First group views theoretical aspects of black swan concept. Second group examines black swan's effect and how they affect after the event has happened. Last group examines, could black swan events be prevented somehow. Table contains an overview of all the studies that were included in the sample. The table shows the type of paper (qualitative, quantitative, conceptual, et cetera), the sample size and the characteristics, group connections in the systematic review and the key findings.

(text continues on page 36)

Table 2: Studies and Key Findings

No.	Article	Type	Sample size	Sample Characteristic	Connections	Key findings
01	Ajmi, El-montasser, Hammoudeh & Nguyen (2014)	Qualitative	- 11 countries	- 11 MENA countries - Daily oil prices from 2.7.2007 to 27.8.2012	- B	- Oil prices and MENA stock markets interact in a nonlinear manner. - The signs of changes in the causing variables are important for detecting the true causality links between the variables. - The nonlinear causality is more pronounced in the case of the Brent than West Texas Intermediate oil prices.
02	Akkermans & Wassenhove (2013)	Conceptual			- A, C	- Grey swans will be increased - Importance of understanding grey swan business tsunami - 4 ways avoid grey swans: 1. Early spotting, 2. Fast decision-making, 3. Agile supply network, 4. Focused research
03	Aleskerov & Egorova (2012)	Quantitative		- Returns of the stock index S&P500 from August 1999 to December 2009	- C	- Black swans cannot be detected with article's model, grey swans can be. - Detecting grey swans brings a small profit in long run.
04	Allington, McCombie & Pike (2017)	Conceptual			- A	- The subprime crisis could have been predictable by anyone with a detailed knowledge of financial markets and the LTCM crisis.

05	Almudhaf & AIKulaib (2017)	Qualitative	-4 investment quality metal's daily prices in US dollars	- Gold, silver and S&P 500 from January 1968 to March 2016. Platinum and palladium from April 1990 to March 2016	B	<ul style="list-style-type: none"> - Black swans can affect to metals prices. - Metals do fluctuate, but value returns. - Timing is impossible to predict, buyers should hold all the time.
06	Ashta (2016)	Journal article/ Interview	One organization	Microcredit organization in India	A, B	<ul style="list-style-type: none"> - Black swans can be government made -Black swans can be teleological (politicians) - Black swans are very difficult to limit/control
07	Bekiros, Boubaker, Ngyen & Uddin (2017)	Quantitative		<ul style="list-style-type: none"> - BRICS countries stock portfolio - 3-month gold future prices 	B	<ul style="list-style-type: none"> - Investing in gold is becoming more popular and it reduce fluctuation in the long run. - Gold acts as a diversifier both normal and bear markets in the BRICS countries, but it is not a hedge or a safe haven.
08	Bogle (2008)	Journal article			A, C	<ul style="list-style-type: none"> - Black swans are unavoidable
09	Booth & Mazzawi (2008)	Journal article			A	<ul style="list-style-type: none"> - 2007 financial crisis was not a black swan, but combined fault of different parties. It was seen in some form before actualization by many.

10	Borisom & Hamm (2010)	Journal article			A	<ul style="list-style-type: none"> - Fact-alone perspective provides no effective guidance on issues where there are little or no frequency data - Unlimited faith in historical data leads to overconfidence and excessive risk taking - A system based solely on historical fact inevitably lurches from crisis to crisis - The Bayesian perspective provides more accurate and powerful results regardless the amount and quality of the data
11	Carmeli & Schaubroeck (2008)	Qualitative	- 30 managers	<ul style="list-style-type: none"> - Snowball sampling method - 217 companies, 75,5% private companies - two-step research model 	A, C	<ul style="list-style-type: none"> - Learning is a critical component to crisis management - Managers should remove employee actions toward failure which were previously effective, but which have now proven to be false - learning from failures is critical to organization's crisis-preparedness, it may help to identify weak signals - previous crisis might make organization's more tolerant to future crisis
12	Carsamer (2016)	Literature review & quantitative	Five countries: South Africa, Egypt, Nigeria, Ghana and Kenya	<ul style="list-style-type: none"> - Regional bilateral trade rate sample period from first quarter of 1990 to 2013 final quarter - Currency US dollars - Data from IMF 	B	<ul style="list-style-type: none"> - Exchange rate co-movement for economies that depend predominantly on trade is high, and such economies are riskier and less resilient to crisis.

13	Chawla, Mangaliso, Knipes & Gauthier (2012)	Literature review		- Historic literature review	A	- Modern technology adds information and capital flows which may increase fluctuation
14	Christiansen & Thrane (2014)	Qualitative	23 managers	- Data from monthly risk update meetings - Military and civil managers - 1-year worth of monthly risk reports	C	- Risk reports communicate information between organizational levels, but frontline managers can add a political nuance to risk, so which should be noticed
15	Davidson (2010)	Conceptual			A	- Nassim Taleb's "black swan" argument regarding uncertainty is equivalent to Frank Knight's epistemological concept of uncertainty
16	Davidson (2012)	Conceptual			A	- Risk managers should realize understand the economic system is nonergodic - A market-maker institution that is trustworthy and has sufficient resources provides security
17	Dietz (2011)	Qualitative		Empirical examination of key theoretical points using a probabilistic integrated assessment model	B, C	- Economic analysis of climate change depends greatly on low-probability, high-impact events - A regional catastrophes are likelier than a global - Regions most likely to suffer a catastrophe are India and Southeast Asia, Africa and the Middle East, and Latin America, the only region to escape a

						<p>catastrophe altogether is the former Soviet Union and Eastern Europe</p> <ul style="list-style-type: none"> - There are several other potential catastrophes which are much less noticed
18	Ding, Gerst, Bernstein, Howarth & Borrsuk (2012)	Quantitative	- 24/16 nations	Long-annual data on growth in real per capita personal consumer expenditure for 24 nations and on asset returns for 16 nations	C	<ul style="list-style-type: none"> - society is substantially more averse to risk than typically assumed in integrated assessment models - Risk preferences vary among nations. - Higher aversion to risk increases HILP-event prevention
19	Emblemsvåg (2008)	Quantitative	One case study	<ul style="list-style-type: none"> - Åknes case study - Monte Carlo method used to estimate the probability of accident 	C	<ul style="list-style-type: none"> - Limited data of natural disaster do affect the accuracy of predictions
20	Estrada (2009)	Quantitative		Dow Jones Industrial Average Index between 1900-2006	B	<ul style="list-style-type: none"> - Large daily swings that have a significant impact on long-term performance - Black swans have a massive impact on long-term performance
21	Feduzi & Rundle (2014)	Conceptual			C	<p>Bacon's method offers rational procedure for exploring possibilities. It shows how the processes of generating and evaluating hypotheses can play supporting roles. It provides the resources for developing prescriptive approaches to state space construction and that may help make</p>

						inroads on the problem of organizations being blindsided by black swan.
22	Flage & Aven (2015)	Qualitative		Theoretical risk classification by literature	A, C	<ul style="list-style-type: none"> - Black swans can be subjective - Unknown unknowns and unknown knowns have been linked to black swan type of events and known unknowns to emerging risks
23	Follain (2013)	Qualitative/ Conceptual	Case study	Case study of relevant literature	A, C	<ul style="list-style-type: none"> - Taleb's overly simplistic narratives could be addressed by people outside the field - Ongoing stress test and new adjusted rules to market could protect against upcoming financial crisis (black swans) - More outlier research is needed
24	Higgins (2013)	Qualitative	20+ experts	<ul style="list-style-type: none"> -Examines Black Swan events and tests impact on the accuracy of short term forecasts -six month bi-annual survey of key Australian property -between 2005-2011 	C	<ul style="list-style-type: none"> - Statistical tests showed inconsistencies with the expert forecasts to actual performance - All the experts appeared to miss the start of the Global Financial Crisis in the December 2008 - At times, simple "no change" forecast was better than experts
25	Hilal, Poon & Tawn (2011)	Quantitative	1052 daily closing value	<ul style="list-style-type: none"> - 1052 closing values for the S&P500 index - from March 26, 2004 to May 30, 2008 	C	<ul style="list-style-type: none"> - Approach can address losses outside the range of the historical data and, so, it is a useful technique for estimating hedge ratios that emphasize the downside risk of a portfolio

26	Hyung & Vries (2012)	Quantitative		- Simulation using an estimate of the scale of the S&P 500 index as a representation for the market factor	C	- The fat tail phenomenon is well recognized and popularized as the black swan - The fat tail feature produces more focused portfolios
27	Ilevbare, Probert & Phaal (2012)	Qualitative	5 case studies	- In-depth semi-structured interviews with roadmapping experts - Exercise from US, UK, Canada and Finland	C	- To be more successful risk management must start with a consideration of uncertainty and go beyond the widely accepted and standard risk management process
28	Jebari (2014)	Conceptual			C	- Engineers safety/safety barriers could provide answer to black swan extinction events
29	Jovanović & Pilić (2017)	Qualitative	19 risks	- 19 Risk from 4 different risk group in ERRAs (emerging risk representative applications) considered as sources of 'multiple risks' in iNTeg-Risk project	B	- The perceptions of ancillary risks and trade-offs are even more variable than the already often very contradictory perceptions of target risks directly pertinent to the respective technologies - The wish to develop and promote the technology in risk-adverse societies can result in blindness for ancillary risks - Paper's framework deals with the trade-offs of risks both in space and in time
30	Knudsen (2010)	Journal article		Environmental problems and black swan evaluated	B	- Environment movement may benefit from 2007 black swan financial crisis, if

				through earlier non-environmental black swan event		global warming is seen as a similar event which should be taken seriously
31	Langley (2013)	Conceptual			C	<ul style="list-style-type: none"> - SCAP is techniques designed to ensure preparedness for the 'black swans' of HILP events - Both bank stress testing and catastrophe planning are problematizations of the future that work primarily with uncertainties rather than risk probabilities
32	Lettieri, Masella & Radaelli (2009)	Systematic review	- 56 articles	Disaster management literature between 1980-2006. Academic journals and peer-reviewed published papers, excluding working papers and books. Both thematic and descriptive analysis	A	- Through both the analyses the authors argue for scholars in disaster management specific streams for further research and for providing practitioners with a state of art of disaster management discipline
33	Lindaas & Pettersen (2017)	Conceptual			A, C	<ul style="list-style-type: none"> - It's possible to predicting extraordinary high-impact events as unlike Taleb claims. A broadening of approaches, including like communication, can contribute to improved predictions. However, communication can work both ways. - De-blackening is possible, not always work

						- Investment in predictive methods and techniques in no waste of resource
34	Lockamy (2011)	Qualitative	10 companies	10 casting suppliers to a major US automotive company	C	- Bayesian networks can be used as an effective benchmarking tool for decisions regarding current and prospective suppliers based upon their potential impact on the buyer organization
35	Lockamy & McCormack (2012)	Qualitative	15 companies	15 casting suppliers to a major US automotive company	C	Bayesian networks methodology can be used to develop supplier risk profiles to determine the risk exposure of a company's revenue stream. The supplier risk profiles can be used to determine which risk events which have the highest impact and probability.
36	Makridakis, Hogarth & Gabe (2009)	Conceptual			A, C	- Subway and Coconut uncertainty, mixture also possible - Downgrading risks is in human nature - Assessing uncertainty: 1. Accepting the existence, 2. Assess the level, 3. Augment the range of uncertainty considered in the previous step
37	Makridakis & Taleb (2009)	Conceptual			A, C	- Accurate forecast is possible but fails in complex system - People reaction affect to future outcomes - In low predictability: 1. Avoid the illusion of control, 2. Protective strategies, 3. Being prepared, 4. Proactive strategies, 5.

						The VC approach, 6. The maxmin approach, 7. Concentrating on uncertainty - Globalism has changed world more volatile because events are combined
38	Markmann, Darkow & Graeth (2012)	Qualitative	80 experts	- Online survey - Experts: 55 from industry, 16 from science and 9 from politics - Survey related to wicked problems	C	- Delphi method can assist in reducing uncertainty and thereby the companies' susceptibility and vulnerability to various kinds of disruptions
39	Marsh & Pfliederer (2012)	Quantitative		- S&P VIX index - 21 year period	C	- Black Swan surprise virtually disappears for S&P Index returns when it's measured relative to the standard deviation of the conditional S&P distribution - Some models, enhanced information flows speed up contagion effects and systemic black swan events - Black swans are hardly immutable; nor does that moniker provide any insight is the becoming manageable or not
40	Maslen & Hayes (2016)	Conceptual			A, C	- Black swans might be able to prevent via information sharing - Both the processes of mediation and synchronization require social practices to transfer, translate, transform, and distribute knowledge between people

41	Masys (2012)	Qualitative	2 case studies	<ul style="list-style-type: none"> - 2010 BP oil spill - 2011 tsunami nuclear accident - cases analyzed through the lens of actor network theory 	C	<ul style="list-style-type: none"> - Scenario planning and red teaming does not predict precise future, but bunch of them. - Black swan might not be revealed (grey swanned)
42	Mikes (2011)	Qualitative	- 2 case studies	<ul style="list-style-type: none"> - 5 major banks over 2001-2010 - 53 interviews 	A, C	<ul style="list-style-type: none"> - Black swan has increased interest to risk management - Over the last decade, a growing number of practitioners and commentators have been recasting a firm's strategic, IT, legal, and compliance uncertainties as additional and distinct risk categories
43	Milanesi, Guercini & Waluszewski (2016)	Qualitative	2 case studies	- paper utilizes published studies on the changes of the textile/fashion companies located to the Prato area in Italy	A	Change appears to be the product of antecedents affecting the dynamics of specific relations, which are an important factor in causing change in business activities; they may be positive or negative, but they are always decisive. Black Swan from the ID standpoint, appears less surprising when interpreted through an interactive approach, focused on the possibilities and constraints of relational processes across time and space.

44	Miller (2009)	Literature review/ Conceptual		Organizational and sociocultural literature illustrate the possibilities for moving beyond modernist assumptions in organizational risk research	A	The directions discussed for future research encourage both theoretical and methodological innovations within organizational risk research
45	Millett (2010)	Journal article			A	<ul style="list-style-type: none"> - Critique: Taleb underestimates the power of long term trends as a basis for strategic planning, discontinuities are no automatic. Scenarios are blandly jumped over, method for suckers - Adds to new edition: black swan is subjective and Investing in barbell strategy
46	Mueller & Stewart (2016)	Journal article			A	<ul style="list-style-type: none"> - Describe how reactions to events decides if the event itself is transforming into black swans due to an aggressive reaction - Criticism toward Taleb's view of social life being produced by sequential "shocks and jumps" - Agrees with the importance of extreme events
47	Nafday (2009)	Conceptual			A, C	<ul style="list-style-type: none"> - Black swans separated from grey swans - Presents: Prevention strategies, Risk-Reduction strategies, Risk Transfer Strategies, Design-Based Strategies

48	O'Donnell (2005)	Conceptual			C	- Creates a system-thinking framework for COSO to identifying the various events that could hinder the ability of a business unit to achieve its operating objectives
49	Olson & Wu (2013)	Journal article/ An article review	One case study	- Review of Eyjafjallajökull volcano case study focusing how HILP can affect to organizations	B	- Highly optimized supply chain networks are inherently risky, in part because they eliminate most system slack in order to lower costs
50	Olson, Miller & Wohar (2012)	Quantitative	8 regions/ countries	Bloombergs daily LIBOR-OIS Spread and a Global credit default swap (CDS) index between 1.1.2006-31.8.2010	B, C	- Black swan appeared in smaller economies prior to that in large ones during financial crisis - Only shocks to the US LIBOR-OIS spread has any statistically significant effects after 30 days
51	Paltrinieri, Tugnoli, Buston, Wardman & Cozzani (2013)	Conceptual			C	- DyPASI features as a tool to support emerging risk management process, having the potentiality to contribute to an integrated approach breaking "vicious circles", helping to trigger a gradual process of identification of previously unrecognized atypical scenarios.
52	Paltrinieri, Khan & Cozzani (2015)	Qualitative	One case study	The BP Texas City refinery accident in 2005	C	- Need of safety culture and decision-making processes capable to deal dynamically with emerging and increasing risk issues

						- Capturing the dynamic evolution of internal and external risk conditions does not only support more effectively critical decisions of the industry sector, but also improve the general safety
53	Paltrinieri & Reniers (2017)	Conceptual		Studies dynamic risk analysis for Seveco sites	C	- Complementary methods addressing dynamic risk analysis on different levels, in order to make sense of the data collected: dynamic hazard identification, dynamic analysis of initiating events, and dynamic analysis of consequences
54	Rheinberger & Treich (2017)	Conceptual			B	- Big catastrophes that are going to increase both in frequency and size - Some general risk assessments do not include important dimensions such as the sheer size of a catastrophe or the disutility of bereavement - General catastrophe aversion is questionable
55	Räikkönen, Pilli-Sihvola, Kunttu, Yliaho, Jähi, Zuccaro & Cogliano (2014)	Qualitative	Two case studies	- Two pilot cases: Extreme winter storm in North of Finland and major earthquake in Italy. - Study is part of CRISMA project	C	- Practical approach for the economic assessment of long-term mitigation investments for crisis management, designed to support planning and decision-making - Covers the influence of economic impacts of mitigation measures and uncertainty on decisions

56	Santos, Alves & Hammoudeh (2013)	Qualitative		three unconditional EVT models based on the i.i.d. assumption	C	The recommendation to decision makers is that at times of extreme and rare events they should estimate market risk with HQ models such the DPOT and Quasi- Port models which perform well with very small probability values.
57	Schurr, Rodensky & Erev (2014)	Quantitative	- 48 students	- Participants used their show-up fee which they could lose - Their risk assessment were examined via several scenarios	A, C	- Study revealed two contradictory effects: direct studies of experienced utility reflect overweighting the peak (rare and most extreme) experience, but studies of decisions from experience reflect underweighting of the peak and reliance on the frequent experiences
58	Sheffi (2005)	Journal article			C	- Flexibility is important for companies to protect themselves against HILP-events
59	Siomkos (1999)	Quantitative	- 384 consumer	Consumer had to have owned either or both products in last two years	B	- consumer links manufacturers reputation directly proportionally to product liability - taking responsibility reduce customers outrage toward company - consumers tend to hold the company less responsible if product re-call are made - a company which faces positive external effects during a crisis will be held the least responsible for the harm

60	Sniedovich (2012)	Conceptual			A	- Critique: Taleb's solution to the Black Swan phenomenon is, to build the world so that it is resistant to Black Swans, hence, to forecast errors, in which case forecast errors, hence uncertainty, would become inconsequential
61	Taylor & Williams (2009)	Quantitative	Several market and interest rates from September 2006 to August	Rates examined through recent no-arbitrage models	B	- expectations of future interest rates and counter-party risk are major factors in explaining the spread between interest rates on lending and the overnight rate - Implications for future macroeconomic research - Implications for policy
62	Terzi (2010)	Conceptual			A	- Outliers are always possible - Past observations are too small sample size to predict probability of extremely rare events - Outliers are risk to an investment portfolio or an entire banking system
63	Trakas, Hatziargyriou, Panteli, Mancarella (2011)	Quantitative	Case study	- Simulation in IEEE 24-bus reliability test - Focuses on computing the SRI of the transmission test system subject to severe windstorms - A simulation period of one day (includes the peak demand)	C	- Managing HILP events in power grid is possible with Severity Risk Index - Could open possibility to monitor for other HILP-events

64	Tzezana (2017)	Qualitative	50 experts	- Deconstructing wicked problems into core components, and on crowdsourcing Wikistrat's platform, to suggest core components, rank them by importance and develop scenarios together	C	- framework to thinking and creating scenarios about future crimes and terror attacks relying on the Internet of Things (IoT), and to present a crowdsourcing research based on this thinking, which resulted in both high- and low-probability scenarios with dramatic impact
65	Wardman & Mythen (2016)	Conceptual			A, C	The associated task is to adopt a more expansive and critical view of communicative responses to black swans.
66	Werther (2013)	Conceptual			A	Critique: - Some Taleb's examples does not follow his own black swan idea - Black swans can be forecasted

4. REVIEW OF THE LITERATURE

In this section, the literature will be divided to three previously mentioned categories by themes for closer analyze. Only the relevant findings for the literature review are examined and included to this section due to space restrictions.

First part of this section, which examines theoretical aspects of black swans, tries to create a functional picture how black swan concept is seen in the scientific field and how the concept has evolved since Taleb introduced it for the first time. Second part examines black swans effect. In this part, articles and researches which examined the effects after the black swan events from the literature are analyzed closer. The purpose is to form a general understanding how black swan can affect to its environment. Third part examines, can black swan be prevented and if it can, which methods can prevent them. In the beginning of part two and three, the part's specific theoretic groundwork is revisited.

4.1 Studies related to theoretical aspects

When examining theoretical aspects of literature, it's helpful to divide the theme to two different sequent. To literature which broadens and supports with the black swan concept, and to literature which disagrees with it at some level.

At first, it's interesting to note that there was not any intended indication in the literature which would have been disagreeing with Taleb's world view. This should mean that most of the scientific field, where the literature was collected, accepts world as a nondeterministic or teleological, dynamical complex system. This cannot be taken as a huge revelation, since deterministic world view is not precisely known as scientific one, but it's an interesting side note. This should also indicate that critique against black swan concept is mostly addressed toward Taleb's own nuances than the black swan concept itself, due to highly similar world view where world is seen as a dynamic entity.

Reviews literature circles efficiently around theme of nondeterministic and questions, if future can be predicted from the past. According to Davidson (2012), economic system is nonergodic which means that predicting the future by examining the average past is inefficient or maybe even impossible. Borisom and Hamm (2010) takes it even further in their research, where was found, that fact-alone perspective provides no effective guidance on issues if there are little or no frequency data. Unlimited faith in historical

data can lead to overconfidence and excessive risk taking. A system based solely on historical fact will inevitably lurches from crisis to crisis. According to them, Bayesian inference method is often a superior method when past is analyzed to predict the future. Terzi's (2010) article agrees with the notion that past observations are often too small sample size to predict probability of extremely rare events. Schurr, Rodensky and Erev's (2014) research revealed two contradictory effects: direct studies of experienced utility reflect overweighting the peak (rare and most extreme) experience, but studies of decisions from experience reflect underweighting of the peak and reliance on the frequent experiences. These four researches support with Taleb's assumption that past events cannot be used to predict future events precisely and the predictions can be misleading due a subjective researcher (Taleb 2007: 84, 190).

Milanesi, Guercini and Waluszewski (2016) studies dynamism further in their research. They notice that change appears to be the product of antecedents affecting the dynamics of specific relations, which are an important factor in causing change in business activities; they may be positive or negative, but they are always decisive. Black Swan, appears less surprising when interpreted through an interactive approach, focused on the possibilities and constraints of relational processes across time and space.

Also, the meaningfulness of prediction is also questionable. Higgins (2013) noted in his study how almost every expert appeared to miss the start of the global financial crisis in 2008. His researches statistical tests showed inconsistencies with the expert forecasts to actual performance and he concluded, that sometimes simple "*no change*" forecast was better than experts. Taleb himself sees that it's useless to try to prevent black swan, but organization should establish themselves a black swan proof. Schurr et al. (2014) study revealed that planning is sensitive to rare events, but they are underweighted in on going decision making. Results could explain why emerging issues are problematic if they caused by rare event.

Review's literature gives several suggestions and process Taleb's definition of black swans further. One of the biggest disagreement in black swans is can they be seen and protect against before they happen. Bogle (2008) agrees with Taleb, that black swans are unavoidable. Foresighting and preventing black swans will be review more thoroughly in section 4.3. Davidson (2010) compares Nassim Taleb's "black swan" argument regarding uncertainty is equivalent to Frank Knight's epistemological concept of uncertainty.

Teleological aspects of black swans are also strongly present in the literature. Makridakis and Taleb (2009b) have defined more specifically teleological aspects of black swans in their article. They point out that people's reflection to black swan events may affect the final outcome and how globalism which has connected the world, might actually make black swans more common and powerful. Chawla et al. (2012) agrees with Taleb's view, that modern technology adds information and capital flows which may increase. Ashta (2016) points out in his article, which examines micro-loans in India, how black swans can be teleological and be caused by politicians or government by setting specific laws or regulations. This suggestion will mean black swans can be caused by either deliberate or accidental action. Seeing black swans as a production of manmade active or passive deeds might be important. Mueller et al. (2016) have made similar observations, teleological connections and describes, how reactions to events can decide if the event itself transforms into black swans due to an aggressive reaction.

Taleb has made some significant additions to his second and renewed edition, which the subjectivity of black swans might be the most important. Flage and Aven (2015) supports this and notes that subjectivity of black swans solidifies the concept. Millett (2010) recognizes the same as Flage and Aven, and adds the new barbell investing strategy which was also newly added to the second edition. In the barbell strategy (Taleb 2013:257-258), the investor is both hyper-conservative and hyper-aggressive at the same time and invests approximately 85-90% of the funds to extremely safe investment instruments, like obligations, and invests the rest to highly speculative options in small portions to gain as high as possible leverage. According to Taleb, doing this should prevent effects of possible black swans, because the basic level of investments will not be affected due to safe hyper-conservative investments.

From the literature rises also a couple of terms similar to black swan which may be useful starting points in future research. Makridakis, Hogarth and Gabe (2009a), uses coconut and subway allegory to identify two different types of uncertainty. The delay of a subway means an often happening event with small consequences. Where a coconut falling to a person's head represents, black swanish like, a rare event with huge consequences. Flage et al. (2015) compares black swans to the term unknown unknowns, which was first used by Donald Rumsfeld in 2002. Unknown unknowns are unexpected events which cannot be predicted just like black swans. The term known unknown is an event that is known but predicting when the event will happen is impossible. They relate the term known unknown to grey swans and emerging risks.

One theme which is heavily emphasized by both Follain (2013) and Terzi (2010), is the need for extensive outlier work to understand rare events better. Outliers should not be chased by the price of high probability events. Outlier research could be helped by the fact that in the field of risk management, the interest toward black swans is rising according to Mikes (2011). The directions discussed for future research encourage both theoretical and methodological innovations within organizational risk research (Miller 2009). Mueller et al. (2016) agrees with the importance of understanding extreme events.

From Lettieri, Masella and Radaelli's (2009) systematic review of can be found similarities between general disaster management and black swans. In both, the researched phenomenon is rare and has substantial effects. Of course, phenomenon's rarity does not make it automatically a black swan. So, it can be argued that there are more connections to grey swans than black swans in disaster management due the more general nature of disasters.

One aspect which is completely missing from the literature of the systematic review is the positive black swan phenomenon. Taleb focuses mostly on the negative side of black swans in his book but introduces the positive version quickly, almost as a side note (Taleb 2013:78). Reasons to bypass positive black swans can only be guessed, but they might be related to Taleb's own book narrative which is heavily focused on negative sides of the black swan phenomenon.

One aspect which rises again and again from the literature is the interest to relation between black swan and communication. There are several sources which believe that good organizational communication can reduce the effects of black swans or even prevent the event. This is an aspect to which Taleb does not believe, at least at the highest level. The associated task is to adopt a more expansive and critical view of communicative responses to black swans Wardman and Mythen (2016). Carmeli and Schaubroeck (2008) adds, the importance of learning from failures, which is critical to organization's crisis-preparedness. They also point out that identifying weak signals correctly may help to foresee black swans' effects. Black swan's prevention aspects will be studied closer in later section.

Critique which Taleb has faced can be basically sort out to two categories, can black swan be seen before they happen and problematic examples. Latter category of criticism pointed toward surprisingly toward black swan examples which Taleb mentions in his book. Both Allington et al. (2017) and Booth et al. (2008) argues correctly that 2007's

financial crisis was not a black swan. They point out how the event does not follow Taleb's own definition. But they miss the fact that even Taleb does not think fore mention event as a black swan (Taleb 2013: 379). The book *Black swan: The impact of the highly improbable*, is heavily related to 2007's financial crisis because it published at the same year as the crash began and some could argue the book offered an easy explanation for the event in the time when it was needed and so became the posterchild of the event. But the book was actually published before the market crash. At least in the literature for the systematic review, there was not any indication that Taleb would have called aforementioned financial crisis as a black swan at some point of time.

Where Allington et al. (2017) and Booth et al. (2008) critique was toward a Taleb was singular example, Werther (2013) has larger issues with Taleb's examples and declares many of Taleb's own examples in the book, not as black swans at all, but they were forecast, and some of Taleb's facts of examples black swans are inadequate or even wrong. Werther mentions Taleb's Lebanon black swan example as a one. "*The Lebanese 'paradise' suddenly evaporated . . . a Black Swan coming out of nowhere transformed the place from heaven to hell*" (Taleb, 2007). The implication is that nobody could see this coming. The truth is many did." (Werther 2013). Werther has his points as some of Taleb's black swans, like *a turkey on a thanksgiving*, can be quite creative, but even though some of Taleb's examples can questionable that does not mean the concept is automatically faulty.

4.2 Black swans' effects

4.2.1 Basics of black swan's effect

To understand why black swans, have so dreadful impact we must understand how black swan's effect works. As Taleb has implicated, he believes causality. If black swan is studied under Taleb's assumption, black swans can be linked to system theory, complex systems and chaos theory.

It's useful to understand the basics of system theory, complex systems and chaos theory. In system theory, every event is affected by several different events and factors. System theory's guiding idea is that everything is formed from individual systems which interact with other systems. These systems can be parallel, like how cells interact together, or they can interact in hierarchy, like cell-tissue-organ-organism system. Complex system is how organism operates in system theory. In complex system, it's impossible to be certain how

upper level systems operates by examining lower level systems. If event happens in a higher system, the effect is not necessarily same in lower system, i.e. the effects in system does not affect in linear manner. Complexity is seen as the source of sudden and unexpected changes. (Laukkanen 2013:58-59). Unexpected changes occur in bifurcation point where a factor affects to the event (Erikson 2013: 70-71). Complex systems do offer the base for chaos theory which explains how chaos is born in complex systems. It can be simplified to a situation where the rapid changes in systems makes it hard to predict the future state of that system due to a nonlinear effect. (Levy 1994).

Limiting and controlling events' effects has been studied extensively in literature. Ashta (2016) has noticed, that black swans are difficult to limit control which emphasize preparing them and their consequence. Olson et al. (2013) noticed in their research, how highly optimized supply chain networks are inherently risky, because they eliminate most of system's slack to lower costs. Findings like theses do make sense because highly optimized systems do rely to other systems which rely to other systems and so on in system theoretic manner. When one fails, it will affect to those which it's connected directly or indirectly.

In short, Taleb and majority of review's literature sees that black swan's effect can spreads from system where it happened to other systems which are directly in touch with it, where it can spread the effect onwards to systems which are not directly in touch with the system where the black swan originally happened. Predicting the spreading and how the black swan affects is hard, and the effects of the event can change from system to system.

4.2.2 How black swan affects systems

Carmaser (2016) studied economies and exchange. According to him, economies where exchange rate co-movement for economies depend predominantly on trade is high, such economies are riskier and less resilient to crisis. Jovanović and Pilić (2017) studied the perceptions of ancillary risks and trade-offs. They are even more variable than the already often very contradictory perceptions of target risks directly pertinent to the respective technologies. The wish to develop and promote the technology in risk-adverse societies can result in blindness for ancillary risks. All in all, it looks like organizations which are more bound to systems around them are more dependent of well-being of those systems. These researches do support Taleb's claim that globalization makes black swans more

common and powerful, since globalization create worldwide systems where black swans can spread easier than further than in local, and smaller, for example nationwide system.

Rheinberger et al. (2017) studied people's attitudes toward HILP catastrophes. They argue, that big catastrophes that are going to increase both in frequency and in size, which is relevant finding and is alarming especially since they also found out, that general risk assessment is often inadequate and do not include important dimensions such as the sheer size of a catastrophe or the disutility of bereavement. Research adds, general catastrophe aversion is not constant, but it changes by system. Study did not link up with Taleb's black swan concept officially, so its statement about increasing number of big catastrophes should not be taken as a testimony for Taleb's claims that globalism strengthens black swans.

Black swan events have also been studied from markets' point of view. Studies connected to markets have often been easier to analyze due exact data. Estrada (2009) studied US stock market and noticed that large daily swings that did have a significant impact on long-term performance, meaning black swans have a massive impact on long-term performance. These long-term performance issues could be explained with problems which spread through systems. Terzi's (2010) research made a notice, that outliers are always possible, and they are a risk to investment portfolios and for the entire banking system.

One instance, which is interested of black swans' effects, is investors. This can be seen from literature, where are heavily connections to several markets. Ajmi et al. (2014) studied how oil prices and MENA stock markets interact, they found out they interact in a nonlinear manner. The signs of changes in the causing variables are important for detecting the true causality links between the variables. The nonlinear causality does change from case to case.

Investors have been searching optional investing methods to diminish the effects of black swans' in their portfolio and popularity of precious metals has increased. Almudhaf et al. (2017) studied, could investing in precious metals to prevent black swan's effect. They found out that even though black swans do affect them, the value will return. They draw a conclusion, that best timing for the purchase is impossible to predict, so buyers should hold all the time. Bekiros, Boubaker, Ngyen and Uddin (2017) shares these views and adds investing in gold is becoming more popular and it reduces fluctuation in the long

run. Gold acts as a diversifier both normal and bear markets in the BRICS countries, but they add that it is not a hedge or a safe haven for investments.

Even Taleb (Taleb 2013:372) himself identified climate change in his book and if black swan is seen in system theoretic view that make all the sense, since climate is connected to everything. Climate change has also been identified in systematic review's literature. Dietz (2017) has studied climate change in economic point of view. He points out, that economic analysis of climate change depends greatly on low-probability high-impact events. A regional catastrophe is likelier than a global. Regions most likely to suffer a catastrophe are India and Southeast Asia, Africa and the Middle East, and Latin America, the only region to escape a catastrophe altogether is the former Soviet Union and Eastern Europe. There are several other potential catastrophes which are much less noticed. If climate change is seen as a black swan, these are aspect which should be taken notice. Knudsen (2010) opportunistically points out that environment movement might benefit from 2007 black swan financial crisis, if global warming is seen as a similar event which should be taken seriously.

Siomkos (1999) has examined the effects of product related repercussions in his studies. Even though he has not studied them connected directly to black swans, his findings are generally useful even without black swans and they may offer directions for later black swan research. Siomkos found out consumers link manufacturers product liability directly to manufacturers reputation. Meaning generally organizations with good reputation are held more accountable for same failures than organizations with worse reputation. Siomkos noticed, that taking responsibility for mistakes reduce customers outrage toward organization. Preventive actions, as making re-call, do lessen responsibility in the face of customers even if failure would happen. Organizations which faces positive external effects during a crisis will be held the least responsible for the harm they might have caused. Siomkos research suggests, that taking responsibility of black swans, if they are self-inflicted, in some cases might help organization to overcome its difficulties in the long run.

4.3 Foreseeing black swans

Question, can black swan be foreseen, is important because it determines how do organization prepares for them. In views, where they cannot be seen, the emphasis leans toward building an organization which is dynamic enough to evade them or robust enough

to endure them. In views, which believe they can be seen, the emphasis is on preventing them or their consequence.

4.3.1 Preparing to unnoticeable black swans

In his book, Taleb presents a view that attempts to prevent black swans happening are useless waste of resources. Trying to prevent them is impossible because they cannot be seen in time to prevent them (Taleb 2013:264). Makridakis et al. (2009b) research shows further Taleb's belief of causality and complexity. They argue that accurate forecast is possible but usually fails due a complexity, which basically make forecasting impossible if the question is even slightest complex. Bogle (2008) agrees with Taleb's belief that black swans are impossible to protect against.

Instead of trying to prevent black swans, Taleb's suggests preparing for their effects. Makridakis et al. (2009b) gives seven-point guideline for actions in low predictability: 1. *Avoiding the illusion of control*, where understanding the lack of control will help the possible psychological stress. 2. *Protective strategies*, where understanding the lack of control may place an organization in risk, protective strategies protects organization from unpleasant events. 3. *Being prepared*. Makradakis' and Taleb's third advice suggests that organization should educate for their employees to prepared for possible events for minimizing wrong actions which may be harmful if an event comes true. 4. *Proactive strategies*, in which organization should prepare reserves which are required to continue its operations. 5. *The VC approach*, in venture capital approach, the organization diversifies their targets across a broad range of investments. 6. *The maxmin approach*, which goes one beyond the VC by seeking out large gains but at a fixed known cost (e.g. buying options or puts), while investing the great majority of the resources in minimal or no risk investments. 7. *Concentrating on uncertainty*, where uncertainty of future is accepted.

Makridakis has studied uncertainty also without Taleb. Makradakis et al. (2009a) examined assessed uncertainty in their article. They make special notice how human nature almost always downgrade the risk under the real estimation. They narrow seven-point guideline to three. 1. Ignoring the facts is not an option, and organizations should accept the existence of uncertainty. 2. Assessing the level of uncertainty and the possible outcomes. 3. Augment the range of uncertainty what is considered in the previous step. Whatever the assessment is, it's probably an underestimated the true level of uncertainty.

4.3.2 Tools and methods to foresee black swans to prevent them

Even though Taleb firmly believes that preventing black swans is impossible, it's useful to question the assumption if they can they be foreseen. If they can, it's possible that some of them might even be prevented. There were several opposing views for the issue in the literature and several methods were used which could help revealing black swans as a whole or partially. This part present tools and methods which are believed to be linked to foreseeing black swans in different fields of operation. Also, the possible outcomes of these experiments are included.

Communication in different forms was one suggested method to prevent black swans which mentioned often in the literature. Maslen and Hayes (2016) believes black swans can prevented via information sharing. Both the processes of mediation and synchronization require social practices to transfer, translate, transform, and distribute knowledge between people. If Maslen's and Hayes' research is taken as an option, organization should pay special attention to how knowledge is translated, because Christiansen and Thrane (2014) study shows that risk reports do transfer information between organizational levels, but frontline managers can add a political nuance to risk which could change the tone of the information. Lindaas and Pettersen (2017) shares same view as Maslen and Hayes and think, it's possible to predicting black swans. According to their research, a broadening of approaches, including like communication, can contribute to improved predictions. However, communication does not always help to recognize possible black swans but might actually prevent the recognition in the case of negative group thinking. Wardman et al. (2016) sees that black swans are hard to detect, and the associated task should to adopt a more expansive and critical view of communicative responses to black swans. Carmeli et al. (2008) points out that identifying weak signals correctly may help to foresee black swans' effects. Learning from failures is critical to organization's crisis-preparedness.

Masys (2012) tested, could scenario planning or red teaming make black swans visible. Because these methods do not predict precise future, but bunch of them, they cannot reveal precise black swans. They theoretically can reveal grey swans, if the future is predicted correctly. According to Markmann, Darkow and Gracth (2012), the Delphi technique has been found to be helpful in examining uncertain world events. They also add Delphi method can assist in reducing uncertainty and thereby the companies'

susceptibility and vulnerability to various kinds of disruptions. Delphi method could provide optional approach to discovering black swans.

Jebari (2014) have examined black swans from engineering point of view and believes that engineer's safety concept or safety barriers could provide answers to black swan extinction events. The limitations for this article are obviously huge due to specific starting point and Jebari's methods might work only in a couple of sectors. Nafday (2009) offers four ways to survive a black swan organization's structure point of view: Prevention strategies, Risk-Reduction strategies, Risk Transfer Strategies, Design-Based Strategies In *prevention strategies*, the major emphasis is on preventing black swans. They are tried to avoid by choosing operation site and procedures correctly, using barriers and training to prevent or minimize black swans. In *risk-reduction strategies*, the potential risk is limited specific part which can be quarantine if needed. This is done with system response control or with some other technological devise. In *risk transfer strategies*, the risk minimized by transferring it with insurances, contracts or sovereign warranty to second party. In *designed-based strategies*, the organization is constructed so that it can survive a black swan, e.g. system resilience through robustness or redundancy. Paltrinieri, Khan and Cozzani (2015) emphasis the need of safety culture and decision-making processes capable to deal dynamically with emerging and increasing risk issues.

Where most literature was focused discovering black swans. Akkermans and Wassenhove (2013) studied how grey swans can be discovered. Discovering grey swans should theoretically be easier than black swan because they are known events. Akkermans and Wassenhove identified four ways discover and avoid grey swans: 1. *Early spotting*, since the event is known, its warning signs are also known. 2. *Fast decision-making*, when risk is discovered the quick decision-making is crucial. 3. *Agile supply network*, is more elusive against threat. 4. *Focused research*, it's needed to make sure that whatever research is develop from observations in practice, it does not gradually drift away from practice and become irrelevant.

One sector which have tried to find an answer to black swans is financing. Methods which are used in financing, probably does not work at organizational level. Follain (2013) has studied outliers and thinks, that ongoing stress test and new adjusted rules to market could protect against upcoming financial black swans and but adds that more extensive outlier research is needed. In his study, Langley (2013) notices that SCAP (Supervisory Capital Assessment Program) has techniques to ensure preparedness for "black swans" of HILP events. He sees, that both bank stress testing and catastrophe planning are

problematizations of the future that work primarily with uncertainties rather than risk probabilities. Aleskerov and Egorova (2012) tried to develop a model which could detect black swans from index, but their model was not functional. Instead it does detect grey swans and can utilize detections to generate small profit in the long run. Santos, Alves and Hammoudeh (2013) makes the recommendation to decision makers, that at times of extreme and rare events they should estimate market risk with HQ models such the DPOT- and Quasi- Port models which perform well with very small probability values.

Hyung and Vries (2012) have studied the fat tail phenomenon which is well recognized and popularized as the black swan and they believe it could produce more focused portfolios. This could produce more protection against black swans. Hilal, Poon and Tawn's (2011) approach addresses losses outside the range of the historical data and, so it's a useful technique for estimating hedge ratios that emphasize the downside risk of a portfolio. Marsh and Pfleiderer (2012) have examined black swan from S&P index and have noted, that the surprise virtually disappears for S&P Index returns when it's measured relative to the standard deviation of the conditional S&P distribution. Some models, enhanced information flows speed up contagion effects and systemic black swan events. Black swans are hardly immutable; nor does that moniker provide any insight is the becoming manageable or not. Olson et al. (2012) have noticed that black swan appeared in smaller economies stock index before in large ones during financial crisis. This should add interest to small economies for hint of a looming black swan.

The interest toward studying black swans have increased in last years. Ilevbare, Probert and Phaal (2012), emphasize that successful risk management, must pay attention to uncertainty and try to recognize patterns outside standard risk management process. Mikes (2011) also points out risk management's becoming role in black swan studies. Interest toward black swans has increased recent years. Over the last decade, a growing number of practitioners and commentators have been recasting a firm's strategic, IT, legal, and compliance uncertainties as additional and distinct risk categories. Risk management's fields interest toward recognizing black swans should produce more black swan research.

One method which could potentially reveal black swans at least in supply chain, maybe even elsewhere, was identified as *Bayesian network methodology*. Lockamy has made extensive studies of Bayesian networks used in supplier selection to reach better supplier contact. The method identifies possible problems and tries to evade them. Lockamy (2011) suggests, Bayesian networks can be used as an effective benchmarking tool for

decisions regarding current and prospective suppliers based upon their potential impact on the buyer organization. According to Lockamy and McCormack (2012), Bayesian networks methodology can be used to develop supplier risk profiles to determine the risk exposure of a company's revenue stream. The supplier risk profiles can be used to determine which risk events which have the highest impact and probability. There should be made a side note, that Lockamy does not directly connect Bayesian networks to black swans, but to similarities between them could grant a starting point for a mapping method which purpose would be searching black swans. This being said, using Bayesian network as profiler for identifying potential black swans or their effect is interesting but highly questionable due highly complex environment which would increase the number potential maps to too high for beneficial use. O'Donnell's research reminds Lockamy's view of Bayesian networks. O'Donnell (2005) conceptualized a system-thinking framework for COSO is somewhat related to Lockamy's view. This framework identifies various events which could hinder the ability of a business unit to achieve its operating objectives. If this framework can identify events which affects to business units' efficacy, maybe it could identify them also in the larger scale.

Feduzi and Rundle (2014) argues, that *Baconian method* offers rational procedure for exploring possibilities. It shows how the processes of generating and evaluating hypotheses can play supporting roles. It provides the resources for developing prescriptive approaches to state space construction and that may help make inroads on the problem of organizations being blindsided by black swan. It's highly questionable if Sir Francis Bacon's scientific model from 1700's is suitable method to identify black swans in modern society.

4.3.2 Foreseeing and preventing nature's black swans

Black swans related to natural disaster should be approached differently than black swans which occur in society and are either man made or caused. Ding, Gerst, Bernstein, Howarth and Borrsuk (2012) studied how risk preference varied among cultures. One general note was that societies are substantially more averse to risk than typically assumed in integrated assessment models. Higher aversion to risk increases HILP-event prevention, which could mean organizations in higher risk aversion systems could possibly evade black swans easier than organizations in low risk aversion societies. Emblemståg (2008) noticed in his research that limited data of natural disaster do affect the accuracy of predictions.

Sheffi (2005), who has studied HILP events has made observation, believes that flexibility can protect companies against HILP events. Observations is similar compared to Talebs suggestions organizations should protect themselves against black swans by constructing their structure to be agile.

Paltrinieri et al. (2017) have studied identifying dynamic risks from catastrophe aspect and especially Paltrinieri has used Seveso sites in his researches which are heavily related to HILP events. In their study, Paltrinieri et al. address dynamic risk analysis on different levels with complementary methods, to analyze collected data. They focus on dynamic hazard identification, dynamic analysis of initiating events, and dynamic analysis of consequences. Seveso sites can suggest further research subjects. Trakas, Hatziargyriou, Panteli and Mancarella (2016) studied power grid accidents and came to a conclusion that Severity Risk Index makes managing HILP events in power grid possible. Severity Risk Index could offer a partial method to monitor for other HILP-events.

According to Paltrinieri, Tugnoli, Buston, Wardman and Cozzani (2013), DyPASI methodology, which is tool for Information Retrieval to Integration of HAZID Process, features as a tool to support emerging risk management process, having the potentiality to contribute to an integrated approach breaking “vicious circles”, helping to trigger a gradual process of identification of previously unrecognized atypical scenarios. Some HILP events and all black swan are atypical scenarios, which would offer a research possibility to create black swan recognizing tool. Tzezana (2017) suggests that the Internet of Things (IoT) framework do offer scenarios about future crimes and terror attacks relying on a crowdsourcing research based on this thinking, which resulted in both high- and low-probability scenarios with dramatic impact. Both Paltrinieri et. al’s and Tzezana’s research could provide useful methods to organizations which study catastrophe based black swans.

Räikkönen, Pilli-Sihvola, Kunttu, Yliaho, Jähi, Zuccaro and Cogliano’s (2014) study offers a practical approach for the economic assessment of long-term mitigation investments for crisis management, designed to support planning and decision-making. It covers the influence of economic impacts of mitigation measures and uncertainty on decisions. If Makridakis et al. (2009b) notion that people’s reaction can change the course of potential black swan is true, approaches which support decision making should be useful methods for potential black swan events.

4.4 Overall evaluation

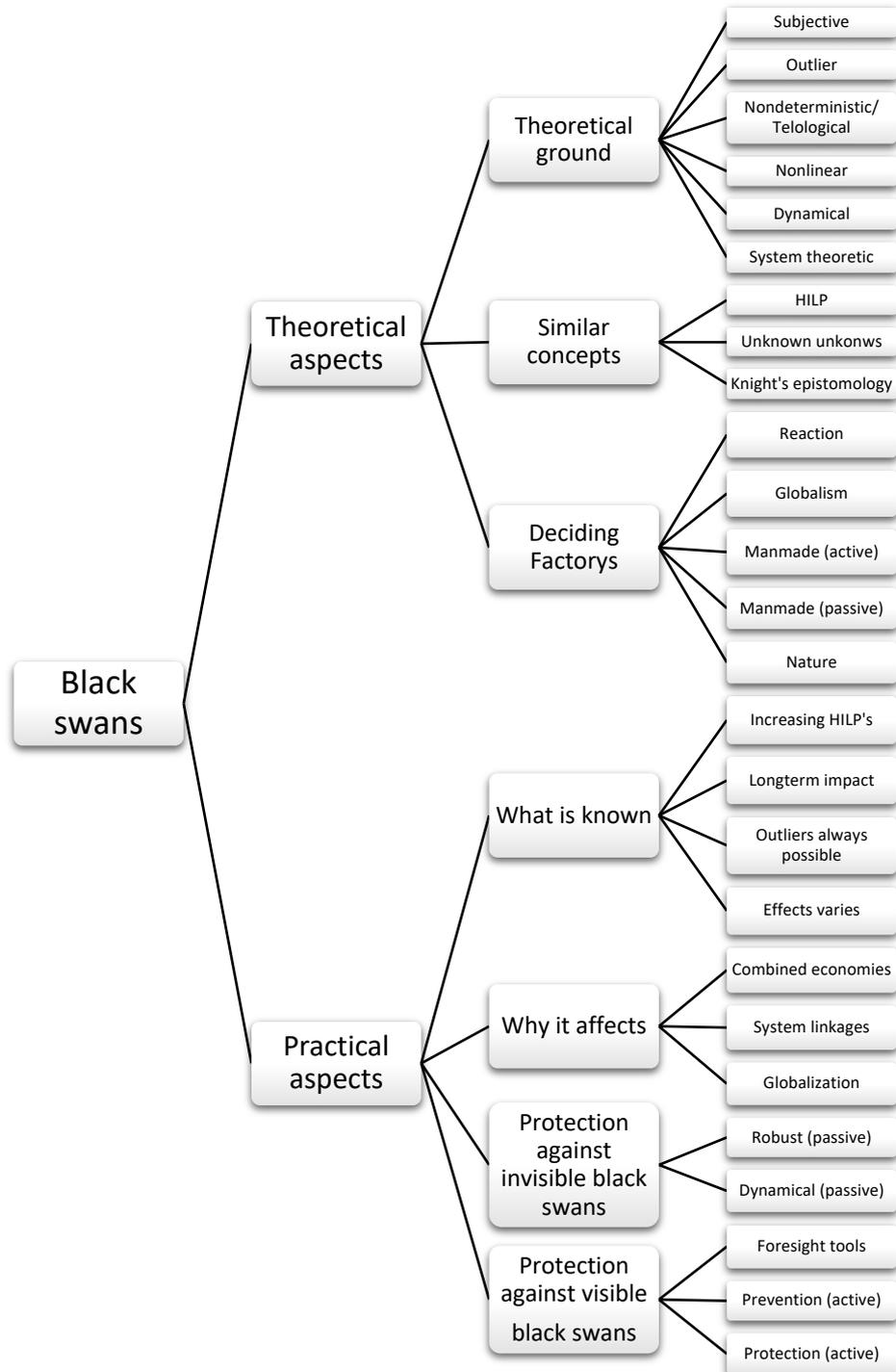
Even though the academic research of Nassim Taleb's black swan concept is relatively young due to book's publication date, the interest toward the concept has been huge. Recent research has been tried to define the black swan's concept to be more precise and studied how the phenomenon could be prevented or mitigated. Before moving towards the directions for future research, some elements that characterize current research will be discussed.

The majority of literature review's articles were divided to quantitative, qualitative and conceptual articles where journals articles and literature reviews were in minority. All in all, there were 22 conceptual, twenty qualitative, 14 quantitative, nine journal articles and four literature reviews. The combined number of aforementioned articles, 69, is three more than number of reviewed articles because three articles used two types of study. If examined closer articles and articles' types, there can be drawn some conclusions. First, most of the black swan articles are either conceptual or journal articles. This could demonstrate, how difficult transforming black swan concept to measurable form is. Most of the quantitative studies which examined black swans focused mostly to its effects which were easier to measure.

Figure 2 (page 51) presents the most important findings of this literature review in one figure. It divides black swan concept to two aspects, theoretical and practical, so that the synthesized data can be presented as efficiently as possible. Theoretical aspects present findings from literature which are considered as core themes of the theoretical base of black swans. Practical aspects include findings which describes on how a specific black swan acts in system where it happens. Figure pays attention to the big picture of black swan's mechanics meaning some smaller findings are included to subcategories due space restriction. Figure 2 is subjective, and it presents the author's view of what is important.

Theoretical aspects include theoretical ground, similar concepts and deciding factors. *Theoretical ground* presents black swan's characteristics and theoretical concepts which guides black swan phenomenon. At theoretical ground, subjectivity (Flagge et al. 2015); outlier (Terzi 2010) and nondeterministic/teleological (Ashta 2016) describes black swan as a phenomenon. It is rare event, which is based mostly on a chance. It might be causal or teleological if there are human related direct or indirect reasons why it happened. It is also subjective meaning some observers may foresee it. Theoretical ground's other terms nonlinear, dynamical and system theoretic (Taleb 2013:216) describe why black

Figure 2: Findings categorized by aspects



swan operates as it does. Black swan works in system theoretic matter, which includes complex systems and chaos theory. It is also nonlinear and dynamic. This explains, why emerging black swans can be difficult to predict and how black swan's effect can spread to new systems.

Similar concepts collect together commonly used concepts which are similar to black swan. HILP (Paltneri et al. 2017), Unknown unknowns (Flagge et al. 2015) and Knight's Epistemological concept of uncertainty (Davidson 2010) might offer the easiest starting point for study of similar concepts. Makridakis et al. (2009a) subway/coconut allegory was deliberately not included to the figure since it's not commonly used. *Deciding factors* collects factors which either causes black swan's or decides will event become a black swan. Some studies (e.g. Mueller et al. 2016) believes that the reaction to potential black swan event may decide how powerful the effects will become. Black swans are believed to become more common due globalization (Makridakis et al. 2009b).

The most interesting part of deciding factors is the three origins of black swan. This thesis does separate the cause of black swan event to three different cause, to nature and both active and passive manmade black swans. This categorizing is based on possible teleological reasons which start a black swan and HILP events which are not caused by man. It must be emphasized that this categorization does exists only in this thesis and there were no similar descriptions in the literature. Nature's black swans are usually HILP events which are not caused by the action of humankind, these kinds of events can be e.g. nature disasters or pandemics. This thesis categorizes, a passive black swan as an event which is unintentionally caused by humankind's action, meaning deed's purpose was not to start a black swan but the action evolved due the world's dynamic nature into one, an example of such event is 2007 financial crash which started from collapse of American housing markets. The system where the event started and mistakes which caused it were made by man but still the event itself was unintentionally. Active black swans is categorized in this thesis as black swan which were caused intentionally, an example of such event is 9/11 attacks.

Practical aspects present how black swans affects, can they be prevented and what is known about black swans at practical level. *What is known* presents the facts which have discovered so far. HILP events are increasing (Rheinberger et al. 2017). Black swan does have long term impact (Estrada 2009) and their effect varies due the dynamical nature of black swans. Black swans are outliers and they are always possible (Terzi 2010).

Why it affects explains why black swan spreads to other systems even outside the system where the original black swan happened. Since black swan is phenomenon which follows system theoretic principles it can spread through system linkages to other systems. Globalization has combined systems of markets and economies together which have made them more close and dependent on each other. This do increase the efficiency of economies, but it also makes them more vulnerable to effects and inefficiencies which spreads through systems. Combined systems create more opportunities to system specific failures which can evolve to a black swan and spread onwards.

Sections, *protection against invisible* and *visible black swans*, combines found methods and practices which are believed to either protect against black swans or prevent them. Actions taken to either prevent or protect against black swans is tightly connected to the belief, can black swans be foreseen. If they can't be foreseen, as Taleb believes, then organization can only protect itself against black swan either building a structure robust enough to outlast black swan or agile enough to evade it (Sniedovich 2012). If organization believes that black swans can be seen, then organization should try to identify emerging black swans using foresight tool. After specific black swan is found organization can either try to prevent black swan altogether from happening or protect itself against that specific black swan.

5. CONCLUSIONS AND LIMITATIONS

5.1 Contribution

By using a systematic methodology to identify 66 key articles, this systematic review examines black swans and related research in academic journals. This review offers a picture how black swan phenomenon is seen from the economic point of view and tries to broaden the view from economics to more universal view so that some of the more challenging question related to black swans could be answered in future research. The review of literature was divided to three group by theme to clarify the specific aspects of each segment. The first group dealt with the theoretical aspects and limitations of black swans. The purpose of the first group was to gather a collective set of black swan mechanics defining articles, which would explain the basic of black swans. The second group examined how black swans' effect in the reviewed literature. The purpose of the second group was demonstrate how black swans can affect the systems where it happens. The third group examined the methods and tools which could foresee or restrict the effects of black swans. The purpose of the third group was to first demonstrate the both views of black swans and then examine the suggested methods or tools to either protect against black swans or prevent them.

Black swan is often seen only as low probability and highly impactful event, as a mere pared down sentence of something what Taleb could have used to market his book. Understanding mechanics behind the popular black swan metaphor are often secondary thing for the great masses who use the term black swan. This review synthetizes studies which gives more scientific explanation for the phenomenon. The dilemma, are black swans foreseeable and therefore can organization protect itself against or even prevent a specific black swan, can be taken as a core contribution of this review. The reason why this is the core contribution, even though the review does not answer the question is the fact, that it is the question which determines how black swans should be handled. Also, if the question is answered, it would immediately set limits for future research.

5.2 Managerial implications

Even though review is theoretical, it offers insights that might be importance for managers in practice. Black swans could be categorized as the current flavor of the month. They are pop cultural phenomena at some level and they get a lot of cover time, meaning they can be seen as more common what they really are. In reality, black swan events have

happened ever since big bang and they will keep happening until the end of time. The current study does not exactly know how to stop or prevent them and at organizational level Taleb offers different dynamic or robust protection solution to stop them. These suggestions are fine, but they might not be the answer for every organization. Overly preparing for an event which is uncertain and does allocate resources, which could be used elsewhere, can be harmful. Most organizations probably cannot optimize themselves to a system which is built to outlast black swan, and even if they can, black swans are erratic, so the protection might not be sufficient after all. Contemplating emergency plans and saving a buffer for future emergencies is always useful, but losing a competitive advantage, due investing for uncertain event, cannot be viable strategy for long run.

5.3 Future research opportunities

In this section, possible future research opportunities are tried to be identified. Earlier theme-based classification is not used in this section because some of the opportunities do intersect several themes or are combination observations from different themes.

One of the biggest problem and the biggest research opportunity which was discovered from literature is the problematic nature of the black swan concept. Because the term is defined by Nassim Taleb himself, it basically means black swan's theoretical concept is also his own intellectual interpretation. Experts have criticized parts his work in several occasions. Where dissenting opinions are healthy thing in science, but the lack of specific theoretical base for black swans, evades the most important question, can black swans be foreseen? Extensive research, which would answer the question, can they be seen, would also set the base line for protecting against them. If they cannot be seen, as Taleb believes, the protection against them though foreseeing is just waste of resources, just like Taleb phrases it. On the other hand, if black swans can be foreseen, it would indicate that Taleb's method to construct systems which are black swan proof might actually be the inefficient method and give competitive advantage to competitors whose systems are optimized without the efficiency loss used to possible black swan threat. This would clarify, should organizations protect themselves passively against possible upcoming black swans or is it possible to actively seek and protect against specific black swan.

After answering the world view question, there would be guidelines for tools which are converting to seek black swans. Right now, the non-existent limits leave every suggestion

to same level without regarding is the suggested method viable or not. This is not necessarily a bad thing, but it complicates finding better methods.

One of the most interesting ideas to find black swans, which were mentioned in several articles was the role of communication in identifying black swans. There are studies, e.g. Maslen et al. (2016) and Lindaas et al. (2017), which have showed at least in some level that communication could reveal potential black swans. Communication's role in black swans could offer several research opportunities. One potential opportunity could be studying can emphasizing communication's importance in current forecasting methods add the probability to find black swans in time. Method like Delphi, could maybe provide insights of potential black swans, if the information produced by one expert, is interpret correctly by another expert quickly enough. Second potential research opportunity, could be examining more thoroughly, what is the part of communication after the black swan has happened. This opportunity would need the assumption Makridakis et al. (2009b), that the reaction of people (or organization) can decide how black swan occurs. If indeed the reaction can change the event, preparing the in the right way could theoretically lessen the effect of the event and communication's part could be define the mutual reaction and the time for the reaction. Third potential research opportunity could be defining a method or standard how relevant individual observations are gathered together and interpreted right. This research path could also be the most important direction.

One potential future research topic could also be more specific separation between natural catastrophe which are seen as a black swan events and so called "manmade" black swans which happen and mostly affect manmade systems. First of all, dividing black swans to two different group would create limits to scientific research which would ease up setting up researches. Secondly, this would help creating forecasting tool research by setting more precise targets where the founded method should work.

As there are connection to teleological aspects (e.g. Ashta 2016) of black swans and there are several black swans, like 9/11 or 2007 financial crash, which were caused by people or organizations, it is fair to question could black swans be weaponized for organizational use. Theoretically an organization could create a manmade black swan to whom effects it would be immune since it has been created by it and should have protected itself against black swan's effects. Of course, it might be ethically frowned upon and due to the complex nature of black swans the outcomes of the event could be hard to predict even it would be a designed black swan. But organizational competition is tough in some industries and shutting down rival's core process could create an excellent competitive advantage.

One possible future research opportunity could be the positive black swans which were completely ignored in the literature and even Taleb (2013:78) mentioned them casually in his book. The more extensive outlier research, which importance Follain (2013) emphasized, could provide useful information when outlier, in this case a positive black swan, is a major enough to pursue. In general, understanding outliers better could answer are they worth of pursuing or are the wasted resources greater than the possible reward.

One valuable research topic could be further examining Taleb's (2013: 280) claims that globalization produce and speed ups black swans. One specific research line could study how black swans contaminates systems which it hits. Perhaps an interesting starting point for a study like that could be following Olson's et al. (2012) notion that some black swan is first viewable in smaller economies. This assumption could provide a smaller and therefore easier system to analyze.

5.4 Limitations

There are several limitations regarding this article. First, even though the reviewed literature was systematic, the fit of the articles was subjectively evaluated. Meaning, it is possible that some relevant articles may have been left out of the review literature. Second, the literature search was related to business and organizational related categories. Meaning there can be highly relevant black swan articles which were outside the sample and was not found in the search. Third, the extracted literature was narrow regarding some themes. Meaning that some of the conclusions has been done with relatively small number of supporting articles. This means some conclusions are strictly connected to very narrow views.

REFERENCES

- Ajmi, Ahdi Noomen, Ghassen El-montasser, Shawkat Hammoudeh & Duc Khuong Nguyen (2014). Oil prices and MENA stock markets: new evidence from nonlinear and asymmetric causalities during and after the crisis period. *Applied Economics*, 46:18, pp.2167-2177
- Akkermans, Henk A. & Luk N. Van Wassenhove (2013). Searching for the grey swans: the next 50 years of production research, *International Journal of Production Research*, 51:23-24, pp.6746-6755
- Aleskerov, Fuad & Lydmila Egorova (2012). Is it so bad that we cannot recognize black swans?, *Economic Letters*, 117:3, pp.563-565
- Allington, Nigel F. B., John S. L. McCombie & Maureen Pike (2012) Lessons not learned: from the collapse of Long-Term Capital Management to the subprime crisis, *Journal of Post Keynesian Economics*, 34:4, pp.555-582
- Almudhaf, Fahad & Yaser AlKulaib (2017) Market timing in precious metals is detrimental to value creation, *Applied Economics Letters*, 24:14, pp.1019-1024
- Ashta, Arvid (2016). Dealing with Black Swan Events: An Interview with Vijay Mahajan, Founder and CEO of Basix, *Strategic Change*, 15:3, pp.625-639
- Bekiros, Stelios, Sabri Boubaker, Duc Khuong Nguyen & Gazi Salah Uddin (2017). Black swan events and safe havens: The role of gold in globally integrated emerging markets, *Journal of International Money and Finance*, 73, pp.317-334
- Bogle, John C. (2008). Black Monday and Black Swans, *Financial Analyst Journal*, 64:2, pp.30-40
- Booth, Geoff & Elias Mazzawi (2008). Black swan or fat turkey?, *Business Strategy Review*, Autumn 2008, pp.34-39
- Borison, Adam & Gregory Hamm (2010). How to Manage Risk (After Risk Management Has Failed), *MIT Sloan Management Review*, 52:1, pp.50-57

- Carmelli, Abraham & John Schaubroeck (2008). Organisational Crisis- Preparedness: The Importance of Learning from Failures, *Long Range Planning*, 41, pp.177-196
- Carsamer, Emmanuel (2016) "The pattern of exchange rate co-movement in selected African countries", *Journal of Economic Studies*, 43: 6, pp.928-953
- Chawla, Chetan, Mzamo Mangaliso, Bradford Knipes, Jeff Gauthier (2012). Antecedents and implications of uncertainty in management: A historical perspective, *Journal of Management History*, 18: 2, pp.200-218
- Christiansen, Ulrik & Sof Thrane (2014). The prose of action: The micro dynamics of reporting on emerging risks in operational risk management, *Scandinavian Journal of Management*, 30:4, pp.427-443
- Davidson, Paul (2010). Black swans and Knight's epistemological uncertainty: are these concepts also underlying behavioral and post-Walrasian theory?, *Journal of Post Keynesian Economics*, 32:4, pp.567-570
- Davidson, Paul (2012). Is risk management a science?, *Journal of Post Keynesian Economics*, 35:2, pp.301-312
- Dietz, Simon (2011). High impact, low probability? An empirical analysis of risk in the economics of climate change, *Climatic Change*, 108, pp.519-541
- Ding, P, M. D. Gerst, A. Bernstein, R. B. Howarth, and M. E. Borsuk (2012). Rare Disasters and Risk Attitudes: International Differences and Implications for Integrated Assessment Modeling, *Risk Analysis*, 32:11, pp.1846-1855
- Dollinger, Mimi (2008). Books on the Horizon, *Business Horizons*, 51, pp.353-357
- Emblemsvåg, Jan (2006). On probability in risk analysis of natural disasters, *Disaster Prevention and Management*, 17:4, pp. 508-518

- Eriksson, Jarl-Thure (2013). Kaaosteoria ja kompleksisten järjestelmien hallittavuus. In: *Miten tutkimme tulevaisuuksia?*, 68-95. 3th Ed. Osmo Kuusi, Timo Bergman & Hazel Salminen. Helsinki etc.: Tulevaisuuden tutkimuksen seura ry. 336 p. ISBN 978-951-98852-3-0.
- Estrada, Javier (2009). Black swans, market timing and the Dow, *Applied Economics Letters*, 16:11, pp. 1117-1121
- Feduci, Alberto & Jochen Rundle (2014). Uncovering unknown unknowns: Towards a Baconian approach to management decision-making, *Organizational Behaviour and Human Decision Process*, 124:2, pp.268-283
- Flage, R. & T. Aven (2015). Emerging risk – Conceptual definition and a relation to black swan type of events, *Reliability Engineering and System Safety*, 144, pp.61-67
- Follain, James R. (2013). The search for capital adequacy in the mortgage market: a case of black swan blindness, *International Journal of Housing Markets and Analysis*, 6:4, pp. 362-382
- Heinonen, Sirkka & Juho Ruotsalainen (2013). Mustien joutsenten ennakointi ja tulkinta menetelmänä ja oppimisprosessina – tuhkapilvien opetuksia. In: *Miten tutkimme tulevaisuuksia?*, 304-314. 3th Ed. Osmo Kuusi, Timo Bergman & Hazel Salminen. Helsinki etc.: Tulevaisuuden tutkimuksen seura ry. 336 p. ISBN 978-951-98852-3-0.
- Higgins, David M. (2013). The black swan effect and the impact on Australian property forecasting, *Journal of Financial Management of Property and Construction*, 18:1, pp. 76-89
- Hilal, Sawsan, Ser-Huang Poon & Jonathan Tawn (2011). Hedging the black swan: Conditional heteroskedasticity and tail dependence in S&P500 and VIX, *Journal of Banking & Finance*, 35:9, pp. 2374-2387
- Hyung, Namwon & Casper G. de Vries (2012). Simulating and calibrating diversification against black swans, *Journal of Economic Dynamics & Control*, 36:8, pp. 1162-1175

- Ilevbare, Imoh M., David Probert & Robert Phaal (2014). Towards risk-aware roadmapping: Influencing factors and practical measures, *Technovation*, 34, pp.399-409
- Jebari, Karim (2014). Existential Risks: Exploring a Robust Risk Reduction Strategy, *Science and Engineering Ethics*, 21:3, pp.541-554
- Jovanović A. S. & V. Pilić (2013). Dealing with risk–risk interdependencies and trade-offs in relation to development and use of new technologies, *Journal of Risk Research*, 16:3-4, pp.393-406
- Knudsen, Odin K. (2010). Turning Black Swans Green: The Vittorio Santaniello Memorial Lecture, *AGBioForum*, 13:2, pp.104-111
- Langley Paul (2013). Anticipating uncertainty, reviving risk? On the stress testing of finance in crisis, *Economy and Society*, 42:1, pp.51-73
- Laukkanen, Jyrki (2013). Systemimallien roolit tutkimuksessa ja suunnittelussa: Uuden dialektisen kokonaisuuden rakentaminen. In: *Miten tutkimme tulevaisuuksia?*, 57-67. 3th Ed. Osmo Kuusi, Timo Bergman & Hazel Salminen. Helsinki etc.: Tulevaisuuden tutkimuksen seura ry. 336 p. ISBN 978-951-98852-3-0.
- Lettieri, Emanuele, Cristina Masella, Giovanni Radaelli (2009). Disaster management: findings from a systematic review, *Disaster Prevention and Management: An International Journal*, 18:2, pp.117-136
- Levy, David (1994): *Chaos Theory and Strategy: Theory, Application, and Managerial Implications*, *Strategic Management Journal*, 15:2, pp.167-178
- Lindaas Ole A. & Kenneth A. Pettersen (2016). Risk analysis and Black Swans: two strategies for de-blackening, *Journal of Risk Research*, 19:10, pp.1231-1245
- Lloyd, Bruce (2008). Book Reviews, *Long Range Planning*, 41, pp.255-230
- Lockamy, Archie III (2011). Benchmarking supplier risks using Bayesian networks, *Benchmarking: An International Journal*, 18:3, pp.409-427

- Lockamy, Archie III & Kevin McCormack (2012). Modeling supplier risks using Bayesian networks, *Industrial Management & Data Systems*, 112:2, pp.313-333
- Makridakis, Spyros, Robin M. Hogarth & Anil Gaba (2009a). Forecasting and uncertainty in the economic and business world, *International Journal of Forecasting*, 25:4, pp.794-812
- Makridakis, Spyros & Nassim Taleb (2009b). Living in a world of low levels of predictability, *International Journal of Forecasting*, 25:4, pp.840-844
- Markmann, Christoph, Inga-Lena Darkow, Heiko von der Gracht (2012). A Delphi-based risk analysis — Identifying and assessing future challenges for supply chain security in a multi-stakeholder environment, *Technological Forecast & Social Change*, 80:9, pp.1815-1833
- Marsh, Terry & Paul Pfeleiderer (2012). "Black Swans" and the Financial Crisis, *Review of Pacific Basin Financial Markets and Policies*, 15:2, pp.1250008-1—125008-12
- Maslen, Sarah & Jan Hayes (2016). Preventing black swans: incident reporting systems as collective knowledge management, *Journal of Risk Research*, 19:10, pp.1246-1260
- Masys, A.J. (2012). Black swans to grey swans: revealing the uncertainty, *Disaster Prevention and Management*, 21:3, pp.320-335
- Mikes, Anette (2011). From counting risk to making risk count: Boundary-work in risk management, *Accounting, Organizations and Society*, 36:4-5, pp.226-245
- Milanesi, Matilde, Simone Guercini, Alexandra Waluszewski (2016). A Black Swan in the district? An IMP perspective on immigrant entrepreneurship and changes in industrial districts, *IMP Journal*, 10:2, pp.243-259
- Miller, Kent T. (2009). Organizational Risk after Modernism, *Organization Studies* 30:2-3, pp.157–180, ISSN 0170–8406

- Millett, S. (2010). In a fowl mood: the argument for Black Swans over predictability, *Strategy & Leadership*, 38:5, ISSN: 1087-8572
- Milner, Brian (2017). Trying to stop black swans offers no protection from risk [online] *The Globe and Mail*. Updated 26 March 2017 [cited 19 December 2017].
- Mueller John & Mark G. Stewart (2016). The curse of the Black Swan, *Journal of Risk Research*, 19:10, pp.1319-1330
- Nafday Avinash M. (2009). Strategies for Managing the Consequences of Black Swan Events, *Leadership and Management in Engineering*, 9:4, pp.191-197
- O'Donnell Ed (2005). Enterprise risk management: A systems-thinking framework for the event identification phase, *International Journal of Accounting Information Systems*, 6, pp.177-195
- Olson, David L. & Desheng Dash Wu (2013). Extreme-event risk management: a review of "Lee, B., Preston, F. 2012. Preparing for High-impact, Low-probability Events: Lessons from Eyjafjallajökull. London: Chatham House.", *Journal of Cleaner Production*, 53, pp.67-68
- Olson, Eric, Scott Miller, Mark E. Wohar (2012). "Black Swans" before the "Black Swan" evidence from international LIBOR–OIS spreads, *Journal of International Money and Finance*, 31:6, pp.1339-1357
- Paltrinieri, Nicola, Alessandro Tugnoli, Jonathan Buston, Mike Wardman & Valerio Cozzani (2013). Dynamic Procedure for Atypical Scenarios Identification (DyPASI): A new systematic HAZID tool, *Journal of Loss Prevention in the Process Industries*, 26:4, pp.683-695
- Paltrinieri, Nicola, Faisal Khan & Valerio Cozzani (2015). Coupling of advanced techniques for dynamic risk management, *Journal of Risk Research*, 18:7, pp.910-930
- Paltrinieri, Nicola & Genserik Renier (2017). Dynamic risk analysis for Seveso sites, *Journal of Loss Prevention in the Process Industries*, 49, pp.111-119

- Rheinberger, Christoph M. & Nicolas Treich (2017). Attitudes Toward Catastrophe, *Environmental and Resources Economics*, 67:3, pp.609-636
- Räikkönen M., K. Pilli-Sihvola, S. Kunttu, J. Yliaho, M. Jähi, G. Zuccaro & D. Del Cogliano (2014). Assessing the economic impacts of crises: a decision-support approach to long-term strategic planning, *WIT Transactions on Information and Communication Technologies*, 47, pp.229-241, ISSN 1743-3517
- Santos, Paulo Araújo, Isabel Fraga Alvesb & Shawkat Hammoudeh (2013). High quantiles estimation with Quasi-PORT and DPOT: An application to value-at-risk for financial variables, *North American Journal of Economics and Finance*, 26, pp.487– 496
- Schurr, Amos, Dotan Rodensky & Ido Erev (2014). The effect of unpleasant experiences on evaluation and behavior, *Journal of Economics Behaviour & Organization*, 106, pp.1-9
- Sheffi, Yossi (2005). Preparing for the Big One, *IEE Manufacturing Engineer*, October/November, pp.12-15
- Siomkos, George J. (1999). On achieving exoneration after a product safety industrial crisis, *The Journal of Business & Industrial Marketing*, 14:1, pp.1-11
- Sniedovich, Moshe (2012). Black Swans, New Nostradamuses, Voodoo decision theories, and the science of decision making in the face of severe uncertainty, *International Transactions in Operational Research*, 19:1-2, pp.253-281
- Taleb, Nassim (2007). *Musta Joutsen: Erittäin epätodennäköisen vaikutus*. 1st ed. Helsinki: Terra Cognita Oy. 424 p. ISBN 978-952-5697-04-9.
- Taleb, Nassim (2013). *Musta Joutsen: Erittäin epätodennäköisen vaikutus*. 2nd ed. Helsinki: Terra Cognita Oy. 510 p. ISBN 978-952-5697-37-7.
- Taylor, John B. & John C. Williams (2009): A Black Swan in the Money Market, *American Economic Journal Macroeconomics*, 1:1, pp.58-83

- Terzi, Andrea (2010). Keynes's uncertainty is not about white or black swans, *Journal of Post Keynesian Economics*, 32:4, pp.559-566
- Trakas, D. N., N. D. Hatziaargyriou, M. Panteli & P. Mancarella (2016). A Severity Risk Index for High Impact Low Probability Events in Transmission Systems due to Extreme Weather, Unpublished
- Tzezana, Roey (2017). High-probability and wild-card scenarios for future crimes and terror attacks using the Internet of Things, *Foresight*, 19:1, pp.1-14
- Wardman, Jamie K. & Gabe Mythen (2016). Risk communication: against the Gods or against all odds? Problems and prospects of accounting for Black Swans, *Journal of Risk Research*, 19:10, pp.1220-1230
- Werther, Guntram Fritz Albin (2013). When Black Swans Aren't: On Better Recognition, Assessment, and Forecasting of Large Scale, Large Impact, and Rare Even Change, *Risk Management and Insurance Review*, 16:1, pp.1-2