Technology Innovation Management Review

February 2020
Volume 10 Issue 2
http://doi.org/10.22215/timreview/1322

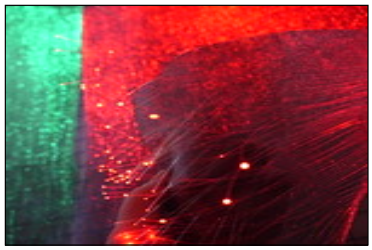

Image credit: Rain Rabbit - Fibre optic fabric (CC-BY)

Insights

Welcome to the February issue of the Technology Innovation Management Review. We invite your comments on the articles in this issue as well as suggestions for future article topics and issue themes.

Technology Innovation Management Review

February 2020
Volume 10 Issue 2

Publisher
The Technology Innovation Management Review is a monthly publication of the Talent First Network.

ISSN 1927-0321

Editor-in-Chief Stoyan Tanev

Managing Editor Gregory Sandstrom

Overview

The Technology Innovation Management Review (TIM Review) provides insights about the issues and emerging trends relevant to launching and growing technology businesses. The TIM Review focuses on the theories, strategies, and tools that help small and large technology companies succeed.

Our readers are looking for practical ideas they can apply within their own organizations. The TIM Review brings together diverse viewpoints —from academics, entrepreneurs, companies of all sizes, the public sector, the community sector, and others —to bridge the gap between theory and practice. In particular, we focus on the topics of technology and global entrepreneurship in small and large companies.

We welcome input from readers into upcoming themes. Please visit timreview.ca to suggest themes and nominate authors and guest editors.

Contribute

Contribute to the TIM Review in the following ways:

- Read and comment on articles.
- Review the upcoming themes and tell us what topics you would like to see covered.
- Write an article for a future issue; see the author guidelines and editorial process for details.
- Recommend colleagues as authors or guest editors.
- Give feedback on the website or any other aspect of this publication.
- Sponsor or advertise in the TIM Review.
- Tell a friend or colleague about the TIM Review.

Please contact the Editor if you have any questions or comments: timreview.ca/contact

About TIM

The TIM Review has international contributors and readers, and it is published in association with the Technology Innovation Management program (TIM; timprogram.ca), an international graduate program at Carleton University in Ottawa, Canada.

Editorial: Insights

Gregory Sandstrom, Managing Editor

Welcome to the February issue of the Technology Innovation Management Review.

The edition begins with a paper by the TIM program's **Tony Bailetti** and **Stoyan Tanev**, the first to be published by the new Scale Early Rapidly Securely (SERS) project community, titled "Examining the Relationship Between Value Propositions and Scaling Value for New Companies". It addresses a basic question, the answer to which has proven to be a significant challenge in practise: what do companies need to do to scale company value rapidly? The authors emphasize that new companies committed to scale early and rapidly need to develop value propositions for diverse parties in their business ecosystem. According to them, the multiplicity of the value propositions forces such companies to address two parallel alignment problems —first, to align the different value propositions and, second, to align the value propositions to companies' scaling objectives. The paper presents topic modelling results based on a corpus of 137 assertions about scaling that were derived on the basis of: (i) insights from 733 articles published in 99 peer-refereed academic journals since 2007; (ii) empirical observations from a sample of 311 companies from 22 countries that have increased their company value to over $1 billion USD since January 1, 2010. The corpus included 19 assertions focusing on value propositions. Conducting an eight topic model led to six stable topics: Fundraise, Enable, Position, Communicate, Innovate, and Complement. The authors found that of the 19 assertions about value propositions, four are connected to Complement, four to Innovate, one to Position, one to Fundraise, and one to Communicate. The results suggest that the multiple value propositions of scaling companies are fundamentally related to their scaling priorities. Thus, the paper contributes to the understanding of how a new company scales company value rapidly.

The second paper by **Hans H. Jung** and **Franz M.J. Pfister** is titled "Blockchain-enabled Clinical Study Consent Management". It focuses on a new approach to health artificial intelligence (AI). The authors identify a key feature of the healthcare system involved in clinical trials and testing, which is still based largely on paper: the written informed consent of patients. They propose a platform business model that aims to digitalise the process of giving consent, both before a clinical trial, as well as potentially re-consenting afterwards, or withdrawing consent, through a dynamic distributed ledger permission system. The decentralising of clinical consent management in a way that increases transparency and removes intermediaries, raises issues involving access to data, data storage, and encryption, as part of a securitization push to protect "sensitive private patient data that cannot be reproduced" (20). The authors present a technical implementation solution built on top of the Ocean Protocol framework to provide basic platform functionality. The paper contributes to the discussion and exploration of AI ethics in the race to build digital platforms for healthcare.

The paper by **Mika Westerlund** follows up on last month's paper in TIMR, "An Ethical Framework for Smart Robots", which addressed the issue of 'roboethics'. This edition features "The Ethical Dimensions of Public Opinion on Smart Robots", in which Westerlund applies the framework that was suggested in his previous paper. Once again focussing on the incoming challenges raised by smart robots, Westerlund makes an analysis of public opinion about smart robots in online articles, gathering short quotes from 117 public comments and structuring them into 11 themes. While "the majority of public discussion focuses on the impacts and implications of robots on society" (33), significantly less attention is given to how people should treat robots, or if they should have "robot rights". The author notes that "the overall tone displayed in this investigation was remarkably negative" (33), in contrast with some previous research on the topic, and reports that "there appears to be a fairly widespread feeling against technological determinism, or at least concern about it in society today" (27). The article offers suggestions to improve the transparency of smart robot product development, and the engage the target market more extensively in the design process with robotics entrepreneurs and manufacturers.

A trio of authors, **Johannes Gasde**, **Philipp Preiss,** and **Claus Lang-Koetz**, present the next paper, "Integrated Innovation and Sustainability Analysis for New Technologies: An approach for collaborative R&D projects". They conduct an analysis on R&D collaborations with particular attention to sustainability-oriented innovation, involving two projects over a period of three years in Germany with academic research and industry partners. The two projects focus on collaborations which are aiming to improve the process of plastics recycling, as well as to reduce microbial contamination of paint in industrial (car body) painting plants. The paper showcases the results in what the authors call an Integrated Innovation and Sustainability

Editorial: Insights

Gregory Sandstrom

Analysis (IISA), which aims to enhance stakeholder dialogue and integration, by generating feedback loops in technology development. It provides a multi-sided assessment regarding sustainability, environmental life cycle, and both economic and social aspects.

The next paper by **Marcos Ferasso** and **Eloisio Andrey Bergamaschi** brings a sometimes-controversial theory in economics to bear on organizational planning for the future. In "Kondratieff's Economic Waves and Future Scenarios Planning: an approach for organizations", the authors provide a short summary of work done in future studies, foresight, forecasting, and technology assessment. Their aim is to make a connection between the long economic waves model by Russian economist Nikolai Kondratieff as it may relate to strategic planning and technology development. The authors suggest that Kondratieff's waves can be used as an effective tool for scenario-building techniques, "as a way to anticipate challenges, opportunities, and threats for organizations' contingency planning" (51). At the same time, they caution that, "[t]he study of long economic waves does not presuppose a certain future to come, but rather can indicate possible signs based on empirical evidence from past events" (60).

The final paper of the edition by **Tony Bailetti** and **Dan Craigen**, continues research from the SERS community, with a goal of "Examining the Relationship between Cybersecurity and Scaling Value for New Companies". The aim of the authors is to "explore the cybersecurity-scaling relationship in the context of scaling new company value rapidly" (62). Drawing on experience from Carleton University's recent 3-year Global Cybersecurity Resource project, they conduct a topic modelling analysis of 137 scaling assertions about company scaling practices. The results include six stable topics (company scaling priorities) and a discussion of the relationship between 17 assertions about cybersecurity management and the scaling priorities. The topic modelling results reveal that 11 of the cybersecurity assertions are related to four topics: Position, Innovate, Complement, and Fundraise. According to the authors, cybersecurity management is an important aspect of a company's scaling master plan and "what a new company does to protect against the malicious or unauthorized use of electronic data" (67) is related to the scaling priorities described by the above four topics.

The TIM Review currently has a Call for Papers on the website for April and May special editions on "Digitalization and its Impact on the International Growth of SMEs", and "The Sharing Economy as a Path to Government Innovation." For future issues, we invite general submissions of articles on technology entrepreneurship, innovation management, and other topics relevant to launching and scaling technology companies, and solving practical problems in emerging domains. Please contact us with potential article ideas and submissions, or proposals for future special issues.

Gregory Sandstrom
Managing Editor

Citation: Sandstrom, G. 2020. Editorial: Insights. *Technology Innovation Management Review*, 10(2): 3-4.
http://doi.org/10.22215/timreview/1323

Keywords: value proposition, scaling company value, topic modeling, topic stability, scaling objectives, clinical study, written informed consent, platform business model, blockchain, health artificial Intelligence (AI), AI Ethics, smart robot, ethics, public opinion, roboethics, content analysis, innovation and sustainability analysis; R&D collaborations; sustainability-oriented innovation; stakeholder dialogue; stakeholder integration, future studies, foresight, strategic planning, economic waves, Kondratieff, cybersecurity, scaling company value, topic model stability, scaling initiatives.

Examining the Relationship Between Value Propositions and Scaling Value for New Companies

Tony Bailetti and Stoyan Tanev

> *"Value equals benefits received for burdens endured."*
>
> Leonard L. Berry,
> Distinguished professor of marketing,
> Texas A&M University

To scale company value rapidly, a new company needs to develop value propositions for diverse parties —customers, investors, partners, suppliers, employees, and other resource owners, as well as align these value propositions with its scaling objectives. The purpose of this paper is to examine the relationships between value propositions for a diverse set of parties, and efforts from a new company to scale company value rapidly. We review the value proposition literature and then examine the relationships between 19 assertions about value propositions, as well as six stable topics that best describe the SERS corpus, which is comprised of 137 assertions about scaling companies early, rapidly, and securely. Conducting a topic model of eight topics led to six stable topics: Fundraise, Enable, Position, Communicate, Innovate, and Complement. We find that of the 19 assertions about value propositions, four are connected to Complement, four to Innovate, one to Position, one to Fundraise, and one to Communicate. A total of eight assertions about value propositions are not connected to any of the six stable topics. This paper contributes to our understanding of how a new company scales company value rapidly, adding an application of topic modelling to perform small-scale data analysis. The findings are expected to be relevant to entrepreneurs and new companies worldwide.

I. Introduction

A new company committed to scaling their company value rapidly must develop value propositions for diverse parties. This includes not just identifying value propositions for customers, but also aligning these value propositions with scaling initiatives, and activities that the new company carries out to scale rapidly. This is reported as a major challenge worldwide, which we surmise is one of the main reasons why most new companies do not scale their company value rapidly.

Managing the value proposition-scaling relationship in a new company context is so far little understood. Even when companies try to shape multiple value propositions, they tend to align them only on a single customer value proposition, yet with little connection to their overall scaling objectives for the short-, mid- and long-term. Thus, many new companies do not scale because they were not in the first place designed to scale in the initial stages of their existence. Interestingly, regional business incubators and accelerators spend significant efforts helping new companies to develop their customer value propositions. These efforts, however, have not resulted in the launch of many companies that can scale company value (Ratte, 2016).

The objective of this paper is to examine the extant value proposition literature and put forward our beliefs about how value propositions relate to scaling new company value rapidly. We conceptualize the management of the value proposition-scaling relationships as being like the management of part-whole relationships (Van de Ven, 1986), wherein value propositions are the parts and scaling company value is the whole.

There is abundant literature on customer value propositions. Unfortunately, this literature is not clear on how new companies should (i) align value propositions for customers, investors, resource owners, and other relevant stakeholders, (ii) align multiple value propositions for diverse parties with specific scaling objectives, and (iii) configure internal and external resources to deliver their portfolio of value propositions.

Examining the Relationship Between Value Propositions and Scaling Value for New Companies

Tony Bailetti and Stoyan Tanev

For our research, we first used the Latent Dirichlet Allocation (LDA) algorithm (Silge & Robinson, 2017: 90) to extract topics in a collection of assertions about what a new company needs to do to scale company value rapidly. Then we described how assertions about value propositions relate to the stable topics. The collections of assertions are included in the Assertions Inventory maintained by the Scale Early, Rapidly and Securely (SERS) community. The SERS community is comprised of researchers and practitioners worldwide, who are committed to produce, disseminate, and evolve high quality resources about scaling companies (https://globalgers.org/). Each assertion is a clear and concise statement that describes an abstract company action, which can be detailed and then implemented to produce outcomes aimed at significantly increasing the value of the new company rapidly. Each statement is transparent, traceable, and regionally inclusive.

The remainder of the article gathers and provides lessons learned from reviewing the value proposition and scaling company value literature streams, describes the method used, presents the results, and provides conclusions.

II. Literature review

Value propositions

"Value proposition" is one of the most widely used terms in business (Payne et al., 2017; Anderson et al., 2006). According to Webster (2002), a value proposition should be the company's single most important organizing principle. Lanning (2000), however, argues that "value proposition" as a term "is frequently tossed about casually and applied in a trivial fashion rather than in a much more strategic, rigorous and actionable manner."

Much of the older literature adopts a one-sided perspective stressing that value is predetermined by the supplier, and then delivered to customers (Kowalkowski, 2011). Few researchers, however, have emphasized the importance of considering the broad range of stakeholders involved in the value creation process (Gummesson, 2006; Mish & Scammon, 2010; Frow & Payne, 2011).

Several excellent literature review papers on this topic have been published recently (Payne et al., 2017; Goldring, 2017; Eggert et al., 2018; Wouters et al., 2018). Payne et al. (2017) define a customer value proposition as, "a strategic tool facilitating communication of an organization's ability to share resources and offer a superior value package to targeted customers" (Payne et al., 2017). For Skålén et al. (2015), value propositions are "promises of value creation that build upon configuration of resources and practices." These definitions emphasize the need for companies' value propositions to consider stakeholder reciprocity, as well as how different actors work together by sharing resources to initiate an offer (Ballantyne et al., 2011; Truong et al., 2012).

Eggert et al. (2018) emphasize that in business-to-business (B2B) markets a value proposition not only communicates value, but also requires the reciprocal engagement of all relevant actors. The study by Wouters et al. (2018) supports the findings of Eggert et al. (2018) and focuses on new technology companies. It argues that such new companies should have at least two value propositions for their business customers: the typical value proposition based on an innovative offer, and a leveraging assistance value proposition, which should convey what the customer company will get in return for providing support and resources. This insight suggests an opportunity to extend the research domain by studying the development of explicit value propositions for other relevant stakeholders, such as investors and external resource owners. The work by Payne and Frow (2014) suggests a process of deconstructing an exemplar organization's value proposition in order to provide an understanding of value elements and resource configurations that could inform the practices of other companies seeking to improve their value propositions.

Value propositions for new companies that wish to scale company value rapidly

There is little systematic knowledge about the factors that enable new companies to scale company value rapidly. For example, extant literature could not explain the high international growth of a representative sample of Canadian companies (Keen & Etemad, 2012). Unfortunately, most existing research does not differentiate between "growing" and "scaling" a business. Neither does it emphasize the need to align a company's value propositions with its scaling objectives. Such alignment implies the need to incorporate scale up objectives into companies' business models, via the configuration of resources and activities that not only create value for customers, but that also allows companies to capture part of that value and distribute it to key resource owners (Teece, 2010; Zott & Amit, 2007). Business models should be examined in terms of scalability, meaning, "the extent to which a business

model design may achieve its desired value creation and capture targets when user/customer numbers increase and their needs change, without adding proportionate extra resources" (Zhang et al., 2015).

Recent studies have advanced an explicit link between the growth orientation of new technology companies and the novelty and attractiveness of their value propositions. According to Rydehell et al. (2018), finding new and innovative ways to offer value to customers is important to achieving high sales growth, as well as rapid geographic expansion to new markets. Malnight et al. (2019), suggest that companies pursue high growth by: creating new markets, serving broader stakeholder needs, changing the rules of the game, redefining the playing field, and reshaping their value propositions. Unfortunately, these insights are difficult to operationalize in a real-life company context.

Resource-based view

The resource-based view of the company (Wernerfelt, 1984) has become influential in understanding how companies attain competitive performance gains based on their resources and capabilities (Alvarez & Barney, 2002). According to Srivastava et al. (2001), "Resource-based view research must always endeavour to identify precisely what customer value in the form of specific attributes, benefits, attitudes and network effects is intended, generated and sustained." Clulow, Barry and Gerstman (2007) examine whether the key resources that hold value for a company also hold value for the company's customers. These studies focus on customer value only and adopt a static perspective regarding resource configuration. This perspective does not help in explaining how new companies can combine internal and external resources to shape value propositions that align with their business strategies.

Later developments of the theory attempted to explain how companies could do that in situations of rapid and unpredictable change (Teece et al., 1997; Eisenhardt & Martin, 2000). This work complemented the resource-based view of a company by focusing on the role of dynamic capabilities, that is, the main routines that allow a company to change and reconfigure its resources when the opportunity or need arises (Eisenhardt & Martin, 2000; Van de Wetering et al., 2017). Previous studies have discussed specific dynamic capabilities routines, such as reconfiguring, learning, integrating, and coordinating (Teece et al., 1997), as well as sensing the environment to seize opportunities and reconfigure assets (Teece, 2007).

According to Van de Wetering et al. (2017), dynamic capabilities are comprised of five dimensions: (i) sensing, (ii) coordinating, (iii) learning, (iv) integrating, and (v) reconfiguring. The authors used these dimensions to develop a strategic alignment model between information technology resource flexibility and the dynamic capabilities of a sample of 322 international companies. Information technology resource flexibility was defined as the degree of decomposition of an organization's IT resource portfolio into loosely coupled subsystems that communicate through standardized interfaces. It was conceptualized as having four dimensions: (i) loose coupling, (ii) standardization, (iii) transparency, and (iv) scalability. Van de Wetering et al. (2017) suggest a positive correlation between a company's degree of aligning information technology resource flexibility and dynamic capability dimensions, and a company's performance.

III. Method

We first use the Latent Dirichlet Allocation (LDA) algorithm (Blei et al., 2003; Blei, 2012) to build a topic per assertion model, and a keywords per topic model, both modeled as Dirichlet distributions. We then describe the connections between the stable topics and (i) the keywords, as well as (ii) the value proposition assertions included in the corpus.

LDA considers every assertion to be a mixture of topics, and every topic to be a mixture of words. Words can be shared between topics and the topics can be shared among assertions. LDA identifies combinations of words that tend to appear together in a way that suggests that specific topics are latently present in the corpus of assertions. In addition, LDA organizes the corpus by clustering the assertions that correspond to each topic. The assertions in each cluster are ranked in terms of the degree of their association with each topic. The topical organization of the assertions enables the thematic substantiation of the topics through a closer examination of the assertions (Boyd-Graber et al., 2017).

Assertions about how a new company can scale company value rapidly

The core team of the SERS community has developed and maintains an inventory of assertions about what companies should do to scale early, rapidly, and securely. The inventory currently includes 137 assertions. The assertions make explicit what is

Examining the Relationship Between Value Propositions and Scaling Value for New Companies

Tony Bailetti and Stoyan Tanev

Table 1. Distribution of keywords that appeared at least three times in the four runs of the topic model

Topic	Keywords
A	*investors, align, scale,* capital, provide, return, scaling, opportunities
B	resource, create, regulatory, combination
C	appropriate, industry, introduction
D	*enable, distribution, funds, liquidity, providers, long, term*
E	owners, resources, chain, stages, members
F	*communication, economics, fundraising, rounds, risks, successful*
G	*propositions, products, innovative, services, track,* stakeholders, deliver, align, offer
H	*customers, benefits, stakeholders,* align, owner

understood about increasing the value of a new company from examining: (i) 733 articles published in 99 peer-refereed academic journals since 2007, (ii) Companies from 22 countries that have increased their company value to over $1 billion USD since January 1, 2010, and (iii) Experience gained while applying the assertions to increase company value.

Topic model

Topic modeling was done using Orange 3.24.1 (Orange, 2020) to extract latent topics from the corpus comprised of 137 assertions and investigate the relationship between the 19 specific value proposition assertions and the topics extracted from the corpus. Each topic represents a set of words extracted from the 137 assertions. The topic-word connection is based on how well the word fits with the topic, while the topic-assertion connection is made based on what topics the assertion addressed. The number of topics used to produce the topic model ranged from 3 to 10. The decision on the number of topics of the final model was made by the authors of the paper based on the joint assessment of the weights of the assertions per topic.

Topic stability

Topic stability was determined by running the final model four times, manually assessing the consistency of topics appearing across the four model runs and topic quality (Xing & Paul, 2018). For each topic, we determined that a topic was stable if five or more keywords appeared repeatedly in the four runs of the final model, and if the weights of the keywords were greater than 2. Topic quality was determined based on a joint judgment of the paper's authors.

Relationship between value proposition assertions and topics

For each topic (regardless whether stable or unstable), the assertions were categorized by topic loading into (i) Equal or greater than 0.6, and (ii) Less than 0.6.

Labelling and describing topics

To label and succinctly describe the topics, we used keywords and assertions with a topic loading greater than 0.6, along with our expertise in examining the content of the text documents (that is, assertions) associated with specific topics.

IV. Results

Corpus

The corpus is comprised of 137 assertions that are expressed using 2,591 keywords. On average, each

assertion has 19 words. Of the 137 assertions, 19 refer to value propositions. Appendix A identifies the 19 value proposition assertions that were derived from articles discussed in the Literature Review section.

Number of topics
The topic modeling analysis iterated between three and ten topics. The authors decided that the best model was the one that had eight topics because the number of assertions that had topic loadings greater than .6 was at least 3 for each of the four model runs, and the results made the most sense in the context of the research topic.

Keyword distribution of four runs of the final topic model
Table 1 provides the keyword distribution for eight topics resulting from four runs of the topic model. Each run provided slightly different results in terms of the composition, ordering, and ranking of words. This is due to the probabilistic nature of the LDA method, which requires performing and comparing multiple runs using the same number of topics.

In Table 1, the rows show the keywords associated with each topic. The keywords *in italics* appeared in all four runs of the topic model. The keywords shown in plain text appeared in 3 of the 4 runs of a topic model. The other keywords are not shown.

Stable topics
Six of the eight topics (that is, Topics A, D, E, F, G, and H), were deemed to be stable because at least five keywords appeared three or four times during the four runs of the model, and each had a weight greater than 2.

Labelling and describing topics
Table 2 provides the topic labels and succinct descriptions of the six topics deemed to be stable. Each topic description built on the keywords shown in Table 1.

Relationship between 19 value proposition assertions and topics
Table 3 provides the 11 value proposition assertions found to be connected to the six stable topics. A value proposition was connected to a topic if its topic loading was equal to or greater than 0.6.

V. Discussion

The topic model results suggest that the initiatives that

Table 2. Topic labels and succinct descriptions

Topic	Label	Description
A	*Fundraise*	Align returns to investors' capital with scale opportunity
D	*Enable*	Make others successful
E	*Position*	Strengthen position among members of the network upon which company depends to scale
F	*Communicate*	Eliminate communication barriers
G	*Innovate*	Continuously deliver innovative products and services and improve value propositions
H	*Complement*	Align benefits to customers, resource owners and other key stakeholders

Examining the Relationship Between Value Propositions and Scaling Value for New Companies *Tony Bailetti and Stoyan Tanev*

Table 3. Value proposition assertions connected to stable topics

Topic	ID	Value proposition assertion
A. Fundraise	A125	Align investor value propositions with company scale objectives so they are mutually reinforcing rather than conflicting
D. Enable		
E. Position	A122	Develop value propositions that support or agree with the value proposition of key members of the company value chain as well as improve the competences of the supply chain
F. Communicate	A118	Develop value propositions for employees that enhance employee satisfaction, psychological attachment, and behavioral commitment toward your company
G. Innovate	A116	Integrate environmental, economic, and social aspects of value into the value propositions for your key stakeholders
	A117	Deliver high value to customers before, during, and after they use your company products or consume your company services
	A123	Continuously find new and innovative ways to offer value to customers in existing and new markets
	A131	Track changes in stakeholders value propositions over time and use the information to align them
H. Complement	A113	Offer benefits to customers, investors and other key stakeholders that are important, differentiated from, and superior to, competing offerings
	A120	Align value propositions for customers, investors and other stakeholders in a way that they support, agree with and reinforce each other
	A121	Develop value propositions for those who pay, not just those who benefit
	A130	To align value propositions to all relevant stakeholders, develop an objective that benefits them all

new companies carry out to scale company value rapidly, can be organized into six topics: Fundraise (align returns to investor capital with scale opportunity); Enable (make others successful); Position (strengthen position among members of the network upon which a company depends to scale); Communicate (eliminate communication barriers); Innovate (continuously deliver innovative products and services and improve value propositions), and Complement (align benefits to customers, resource owners and other key stakeholders).

The 11 value proposition assertions are connected to five of the six stable topics. By "connected", we mean that a value proposition has a topic loading equal to or greater than 0.6. Of the 11, eight value proposition assertions are connected to two topics: Complement and Innovate. The four value proposition assertions connected to the Complement topic focus on aligning value propositions across parties, and offering benefits to multiple parties, not just customers.

The topic Innovate includes four value proposition assertions that focus on 1) integrating social impact aspects of value into the value propositions for all parties, 2) delivering high value to customers before, during, and after they use products or consume services, 3) innovating to create new value; and 4) tracking value propositions.

The value proposition assertion for employees is connected to Communicate, for investors relates to Fundraising, and for value chain members with Positioning.

VI. Conclusions

We reviewed the literature on value propositions and found that there is a need for a better understanding of how new companies manage the relationships between their value propositions to diverse parties, as well as what their initiatives are to scale company value rapidly.

We used topic modelling to examine the relationship between 19 assertions about value propositions and topics extracted from a corpus comprised of 137 assertions about how new companies scale rapidly.

We argue that entrepreneurs should use a multi-party perspective to develop value propositions for their new companies, beyond just a customer value proposition perspective. We also argue that initiatives to scale company value rapidly can be organized into six main topics, and that value propositions to multiple parties are connected to five of these six topics.

The paper's methodology also contributes to the literature on topic modeling. First, it demonstrates how practical insights can be extracted from a small data set, and second it offers a process to measure topic stability for more robust modeling, which researchers can use in future studies.

Acknowledgements
We wish to sincerely thank Professor Michael Weiss and Mr. Daniel Craigen of Carleton University's Technology Innovation Management program, Eduardo Bailetti, CEO of ScaleCamp, and Rahul Yadav, a graduate student in the Technology Innovation Management program for their various contributions to this paper.

References

Alvarez, S., Barney, J. 2002. Resource-based theory and the entrepreneurial firm. In: *Strategic entrepreneurship: Creating a new mindset*, Hitt, M., Ireland, R., Camp, M, & Sexton, D., Eds. Blackwell Publishing: 87–105.

Anderson, J., Narus, J., Van Rossum, W. 2006. Customer VPs in business markets. *Harvard Business Review*, 84(3): 91–99.

Ballantyne, D., Frow, P., Varey, R., Payne, A. 2011. VPs as communication practice: Taking a wider view. *Industrial Marketing Management*, 40: 202–210.

Blei, D. 2012. Probabilistic Topic Models. *Communications of the ACM*, 55 (4): 77–84.

Blei, D., Ng, A., & Jordan, M. 2003. Latent Dirichlet Allocation. *Journal of Machine Learning Research*, 3: 993–1022.

Boyd-Graber, J., Hu, Y. and Mimno, D. 2017. Applications of topic models. *Foundations and Trends® in Information Retrieval*, 11(2-3): 143-296

Eggert, A., Ulaga, W., Frow, P., Payne, A. 2018. Conceptualizing and communicating value in business markets: From value in exchange to value in use. *Industrial Marketing Management*, 69: 80–90.

Eisenhardt, K., Martin, J. 2000. Dynamic capabilities: what are they? *Strategic Management Journal*, 21(10–11): 1105–1121.

Frow, P. & Payne, A. 2011. A stakeholder perspective of the value proposition concept. *European Journal of Marketing*, 45(1/2): 223–240.

Examining the Relationship Between Value Proposition and Scaling Value for New Companies *Tony Bailetti and Stoyan Tanev*

Goldring, D. 2017. Constructing brand VP statements: a systematic literature review. *Journal of Marketing Analytics*, 5(2): 57–67.

Gummesson, E. 2006. Many to many marketing as grand theory. In R. F. Lusch & S. L. Vargo (Eds.), *The service dominant logic of marketing*. Armonk: M. E. Sharpe, pp. 339–353.

Keen, C., Etemad, H. 2012. Rapid growth and rapid internationalization: the case of smaller enterprises from Canada. *Management Decision*, 50(4): 569–590.

Kowalkowski, C. 2011. Dynamics of value propositions: Insights from service-dominant logic. *European Journal of Marketing*, 45(1/2): 277–294.

Lanning, M. 2000. *Delivering profitable value: A revolutionary framework to accelerate growth, generate wealth, and rediscover the heart of business*. Cambridge, MA: Perseus Press.

Mish, J., & Scammon, D. L. 2010. Principle-based stakeholder marketing. *Journal of Public Policy & Marketing*, 29(1): 12–26.

Malnight, T., Buche, I., Dhanaraj, Ch. 2019. Put Purpose at the CORE of Your Strategy. *Harvard Business Review*, 97(5): 70–78.

Orange (2020). https://orange.biolab.si/

Payne, A., Frow, P., Eggert, A. 2017. The customer VP: evolution, development, and application in marketing. *Journal of the Academy of Marketing Science*, 45(4): 467–489.

Payne, A., Frow, P. 2014. Deconstructing the value proposition of an innovation exemplar. *European Journal of Marketing*, 48(1/2): 237–270.

Ratté, S. 2016. The Scale Up Challenge: How Are Canadian Companies Performing? *Business Development Bank of Canada.* https://www.bdc.ca/en/about/sme_research/pages/the-scale-up-challenge.aspx

Rydehell, H., Löfsten, H., Isaksson, A. 2018. Novelty-oriented value propositions for new technology-based companies: Impact of business networks and growth orientation. *The Journal of High Technology Management Research*, 29(2): 161–171.

Skålén, P., Gummerus, J., von Koskull, C., Magnusson, P. 2015. Exploring value propositions and service innovation: A service-dominant logic study. *Journal of the Academy of Marketing Science*, 43(2): 137–158.

Srivastava, R., Fahey, L., Christensen, H. 2001. The resource-based view and marketing: the role of market-based assets in gaining competitive advantage. *Journal of Management*, 27: 777–802.

Teece, D. 2010. Business models, business strategy and innovation. *Long Range Planning*, 43(2–3): 172–194.

Teece, D. 2007. Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal*, 28(13): 1319–1350.

Teece, D., Pisano, G., Shuen, A. 1997. Dynamic Capabilities and Strategic Management. *Strategic Management Journal*, 18(7): 509–533.

Truong, Y., Simmons, G., Palmer, M. 2012. Reciprocal value propositions in practice: Constraints in digital markets. *Industrial Marketing Management*, 41(1): 197–206.

Van de Ven, A.H. 1986. Central problems in the management of innovation. *Management Science*, 32(5): 590-607.

Van de Wetering, R., Mikalef, P., Pateli, A. 2017. A strategic alignment model for IT flexibility and dynamic capabilities: Toward an assessment tool. *Proceedings of the Twenty-Fifth European Conference on Information Systems* (ECIS): Guimarães, Portugal.

Webster, F. 2002. *Market-driven management: How to define, develop and deliver customer value* (2nd ed.). Hoboken: John Wiley & Sons.

Wernerfelt, B. 1984. A resource-based view of the firm. *Strategic Management Journal*, 5(2): 171–180.

Wouters, M., Anderson, J., Kirchberger, M. 2018. New-Technology Startups Seeking Pilot Customers: Crafting a Pair of VPs. *California Management Review*, 60(4): 101–124.

Xing, L. & Paul, M. 2018. Diagnosing and Improving Topic Models by Analyzing Posterior Variability. *The Thirty-Second AAAI Conference on Artificial Intelligence* (AAAI-18): 6005-6012.

Zhang, J., Lichtenstein, Y., Gander, J. 2015. Designing scalable digital business model. *Business models and modelling, Advances in Strategic Management*, 33: 241-277

Zott, C., Amit, R. 2007. Business model design and the performance of entrepreneurial companies. *Organization Science*, 18: 181–199.

Appendix A. Value proposition assertions in the SERS dataset that were examined

ID	Value proposition assertion
A113	Offer benefits to customers, investors and other key stakeholders that are important, differentiated from, and superior to, competing offerings
A114	Develop value propositions that enhance your customers' and suppliers' outcomes, marketing strategies, and competitive advantages
A115	Incorporate elements of value into your value propositions to consumers that address four kinds of needs: functional, emotional, life changing, and social impact.
A116	Integrate environmental, economic, and social

Examining the Relationship Between Value Proposition and Scaling Value for New Companies *Tony Bailetti and Stoyan Tanev*

aspects of value into the value propositions for your key stakeholders

A117 Deliver high value to customers before, during, and after they use your company products or consume your company services

A118 Develop value propositions for employees that enhance employee satisfaction, psychological attachment, and behavioral commitment toward your company

A119 The required investment and the resulting most significant stakeholder benefits should be quantified in specific, measurable, attainable, relevant, and time-bound terms

A120 Align value propositions for customers, investors, and other stakeholders in a way that they support, agree with, and reinforce each other

A121 Develop value propositions for those who pay, not just those who benefit

A122 Develop value propositions that support or agree with the value proposition of key members of the company value chain, and improve supply chain competences

A123 Continuously find new and innovative ways to offer value to customers in existing and new markets

A124 Continuously create new markets and serve broader stakeholder needs

A125 Align investor value propositions with company scale objectives so they are mutually reinforcing rather than conflicting

A126 Recognize what new companies that are scaling rapidly do, assimilate the lessons learned, and apply them to develop and implement your company value propositions

A127 Learn from value propositions of companies that have grown early, rapidly, and securely and apply them to differentiate your company

A128 To align the value propositions for customers, investors, and resource owners, make explicit the benefits: (i) an investor gains by the presence of the customer and resource owner, (ii) a customer gains by the presence of the investor and the resource owner, and (iii) the resource owner gains by the presence of the customer and the investors

A129 To align value propositions for customers, investors, and resource owners, co-create a unique combination of resources that did not previously exist

A130 To align value propositions to all relevant stakeholders, develop an objective that benefits them all

A131 Track changes in stakeholders value propositions over time and use the information to align them

About the Authors

Tony Bailetti is an Associate Professor in the Sprott School of Business and the Department of Systems and Computer Engineering at Carleton University, Ottawa, Canada. Professor Bailetti is the past Director of Carleton University's Technology Innovation Management (TIM) program. His research, teaching, and community contributions support technology entrepreneurship, regional economic development, and international co-innovation.

Stoyan Tanev, PhD, MSc, MEng, MA, is Associate Professor of Technology Entrepreneurship and Innovation Management associated with the Technology Innovation Management (TIM) Program, Sprott School of Business, Carleton University, Ottawa, ON, Canada. Before re-joining Carleton University, Dr. Tanev was part of the Innovation and Design Engineering Section, Faculty of Engineering, University of Southern Denmark (SDU), Odense, Denmark.

Dr. Tanev has a multidisciplinary background including MSc in Physics (Sofia University, Bulgaria), PhD in Physics (1995, University Pierre and Marie Curie, Paris, France, co-awarded by Sofia University, Bulgaria), MEng in Technology Management (2005, Carleton University, Ottawa, Canada), MA in Orthodox Theology (2009, University of Sherbrooke, Montreal Campus, QC, Canada) and PhD in Theology (2012, Sofia University, Bulgaria).

Dr. Stoyan Tanev has published multiple articles in several research domains. His current research interests are in the fields of technology entrepreneurship and innovation management, design principles and growth modes of global technology start-ups, business analytics, topic modeling and text mining. He has also an interest in interdisciplinary issues on the interface of the natural and social sciences.

Citation: Bailetti, T. and Tanev, S. 2020. Examining the Relationship Between Value Proposition and Scaling Value for New Companies. *Technology Innovation Management Review*, 10(2): 5-13.

http://doi.org/10.22215/timreview/1324

Keywords: value proposition, scaling company value, topic modeling, topic stability, scaling objectives

Blockchain-enabled Clinical Study Consent Management

Hans H. Jung and Franz M.J. Pfister

> "I think the biggest innovations of the 21st century will be at the intersection of biology and technology. A new era is beginning."
>
> Steve Jobs

Written informed consent (WIC) is required in the context of voluntary participation in a clinical trial. The trial participant gives WIC in accordance with various regulatory requirements. We present a framework concept for a blockchain-based distributed ledger solution, which aims at implementing simple and secure management of WIC documentation, along the entire data value chain from acquiring consent to academic publication, and (commercially) exploiting the results of a clinical study. This may include (but is not limited to) clinical deployment, security monitoring, and conformity with data privacy and ethical standards. Thus, we present a potential "Health AI" application that goes beyond WIC documentation, to enabling the creation of a holistic data provenance trail graph. Such a framework concept aims to create sustainable value for study participants, clinicians, data scientists, and ultimately consumers. The framework's usefulness is relevant for ensuring the ethical development of artificial intelligence applications in the healthcare domain.

1. Introduction to Subject: Participation in Research Trial

1.1 Relevance of the Subject

Conducting clinical studies includes an obligation to publish results to participants, sponsors, colleagues, and the public (Antes, 2009). ClinicalTrials.gov lists over 304,000 studies with locations in 208 countries (ClinicalTrials, 2019). The German Register of Clinical Trials (Deutsches Register für Klinische Studien, [DRKS]) is the primary registry for Germany. The aim of this registry is as a central contact point to provide the public with a complete and up-to-date overview of clinical trials conducted in Germany. The University Hospital of Freiburg started implementing DRKS as part of a BMBF project in 2017. Since July 1st of that year, the German Institute has continued it permanently for Medical Documentation and Information (Deutsches Institut für Dokumentation und Information, [DIMDI], 2019).

A large number of national and international guidelines must be adhered to in order to ensure the quality of a clinical study. The documentation and archiving of agreement declarations for scientific and medical studies are indispensable, and are required by ethical committees before the start of research work. This assures that the patient voluntarily participates in the study, and additionally that they agree to usage of the obtained results. By giving their consent, the study organizer secures the patient's legal rights, as well as protecting their own.

Written informed consent (WIC) is required in the context of voluntary participation in a clinical study, by the study participant (patient), according to § 40 AMG, § 20 MPG, § 3 (2b) of the Ordinance on the Application of Good Clinical Practice (GCP Ordinance) in the conduct of clinical trials with drugs for human application (European Medicines Agency EMA, 2019). Various formats exist to provide and document informed consent (Synnot et al., 2016).

The rationale for WIC is to provide subjects with the right of access to detailed (patient) information. Additionally, it is meant to provide sufficient time for a patient's reflection, before signing their consent and commencing the clinical trial, which is often documented by means of what's called a "digital time stamp". The physician conducting the study has a duty to inform persons being tested about the study in a personal consultation, and to answer the patient's questions (Purcaru, 2014). This can also be recorded digitally on an individual basis (for example, with a voice

Blockchain-enabled Clinical Study Consent Management

Hans H. Jung and Franz M.J. Pfister

recording) before the patient's declaration of consent is digitally signed and archived.

In clinical practice, WIC has to be defined, evaluated, and approved in advance with representatives of all relevant stakeholders (for example, Clinical Research Organisation, [CRO], patient representatives, sponsors, and ethics committees). To ensure that documentation meets the requirements, both clarification of persons tested, and obtaining of their signatures may only be carried out by actual physicians themselves, based on a standardized template. WIC must also include information on data protection, as well as the right to withdraw consent (Aerztekammer, 2019).

The introduction of EU Data Protection Basic Regulation (GDPR) on May 25th, 2018, changed the requirements for medical research projects that involve the processing of personal data. In the case of studies already in progress before that date, in which participant data continues to be collected afterwards, information sharing is required as a matter of principle (Wenlong, 2018).

1.2 Research & Practice Gap and Research Objective

Researchers, clinics, regulatory authorities, and others have an objective to improve their informed consent procedure in clinical research. Previous research has tested various digitized solutions (Tait, 2015; Synnot et al., 2016; Nugent et al., 2016) using consent systems. As well, previous efforts have been made both to suggest and attempt to implement blockchain solutions for implied consent (Choudhury et al., 2018; Omar et al., 2019; Osipenko, 2019). However, there is currently no available a scalable technical solution that addresses the major challenges of WIC.

The main challenges of WIC include:

- storage,
- standardization,
- subsequent changes (patient/researcher).

In many current cases, paper documentation is still used to retrieve and store analog patient consent forms. This makes it hard to account for subsequent retrieval of documents, personnel changes, water damage, fire, etc., and can lead to ambiguities and damage of documents. In addition, hospitals apply different standard documentation for patient consent forms. Thus, the completeness of stored documents is compromised, and there is no common index created for retrospective archive searches.

Lastly, after successfully conducting a clinical study, there is usually no practical way, either for study participants or researchers, to obtain any subsequent changes to the consent given, or parts thereof. Nevertheless, it might be important to either restrict or extend the consent later on in the medical process, for a purpose that was not considered at the time of data collection (and thus there was no explicit consent for it), in case the data might still be valuable for answering additional research questions. In such a context, there is no practical way of solving the "right to be forgotten", which is now a requirement of the GDPR. This problem addresses how, if a participant wants, subsequent to clinical testing, to withdraw their consent (Wenlong 2018). Associated with this, an inability to change status may also block new business opportunities, for example, when a patient's consent does not include certain commercial applications of the study data.

1.3 Research & Practice Questions and Approach

Primary clinical research is extremely resource-intensive, in terms of time and money. The process of data acquisition can be lengthy in particular (Nijhawan, 2013). We argue in this paper that decentralized and secure management of consent data can help expand the application fields for individual clinical studies with multiple data uses. Such technological implementation can save resources for scientists and research institutes, and lead to advances in the research process. Further standardization, such as pre-formulated templates, can be designed to offer an advantage for ethical committees (IRB counsels) and scientists, which additionally accelerate the complex administrative process.

To trace WICs from end-to-end (E2E) means to make it possible to monitor each individual step of a clinical trial process transparently. This covers data collection, processing, application of machine learning, and deployment of results to the final product. The aim is to provide a ground layer for medical data provenance.

Ultimately, as the technology advances, tracking data provenance trails in a distributed ledger system will enable end-users to understand exactly which input data a machine-generated output (machine learning model prediction) is based on. For example, the system could attest that a predictive algorithm for Parkinson's diagnosis has been trained on 5,000 patient records, all of which have given their consent, from a multi-centre study that includes 27 different countries.

Blockchain-enabled Clinical Study Consent Management

Hans H. Jung and Franz M.J. Pfister

2. Framework Concept to Develop a Blockchain-Based Solution for Written Informed Consent (WIC) with Patient Participation in a Clinical Trial

2.1 As-Is-Situation and To-Be-Situation

For participation in clinical trials, participants (patients or healthy subjects) nowadays must first give their written informed consent (Nijhawan, 2013). The study's protocols must therefore be approved in advance by an ethics committee, while the study's physician manages the operational steps:

- informing study participants,
- obtaining written informed consent (WIC),
- enabling proper storage of WICs,
- ensuring adequate data storage of collected study data.

A declaration of consent, as well as its potential revision in clinical trials, should be transparent for study subjects, and comprehensible for all parties involved.

This paper outlines how to develop and implement a standardized digital process that streamlines the process of obtaining study participants' clinical consent. This is achieved by linking patient consent to ongoing blockchain protocol revisions. In this way, the system will be able to store (off-chain, in decentralized storage) and track (on-chain) patient consent in a secure, more accident-free, publicly verifiable way, through real-time exchange of information.

Our research supports the development, risk assessment, and implementation of innovative distributed ledger business models, based on novel digital solutions. In our work, we applied a toolbox that aimed at developing an individual business model that can be operated economically (Echterhoff et al., 2017).

The first step of our structured research approach was to determine features of the current WIC status quo, as well as the basic functional dimensions for digitized clinical study consent management. We describe the findings in a morphological box (see Figure 1).

Our findings show that it is necessary to replace the status quo WIC paper form used in daily practice for documentation and workflow (from managing patient consent forms to publishing the study's results). Current research results suggest that new digital technology is on the verge of offering new opportunities to map WIC documents in an organisationally and legally secure manner digitally (Benchoufi, 2018; Borioli, 2018). Therefore, we plan to supplement their efforts by contributing a workflow using a blockchain system.

"Blockchain" is a distributed ledger technology, invented in theory in a white paper by the pseudonymous "Satoshi Nakamoto" from 2008, then actualized in practice starting January 3, 2009 with the start of Bitcoin. We believe the decentralised character of "blockchain" systems provides an alternative option for data management, which is conducted "by the social machine and cryptographised to enable various levels of user anonymity and thus greater freedom of participation" (Sandstrom, 2017a). Blockchain enables the recording of information between a variety of operators through a social recording system with data procedures. The recording system is a distributed ledger, in which a block of information is stored in a distributed fashion. The ledger is immutable and is available to all operators through a distributed

WIC Functionality	Status Quo	Digital Solution	Blockchain Solution
WIC Design	Paper	Data file	Template system
WIC Signature	Handwritten	Digital signature	Digital biometric data
WIC Storage	Document folder	Centralized Database	Decentralized database
WIC Content Change	Index	Document management	Blockchain
WIC Security	Locked drawer	Password	Smart contract
WIC Standardization	Template	Digital template	Smart contract
WIC Commercialization	Single use	...	Scalable use based on platform

Figure 1. Morphological box for clinical study consent management

Blockchain-enabled Clinical Study Consent Management

Hans H. Jung and Franz M.J. Pfister

database hosted by each participant (Schacht, 2019). As Sandstrom notes (2017b), "[w]ith blockchain as a globally oriented technology built upon the internet, we are starting to see new opportunities for digital identity provision".

Healthcare, along with many other industries involving identity and consent, is a relevant area in our economy that will be transformed by digital technologies such as blockchain. Numerous new studies and research results have been published in recent years, making it difficult for researchers and practitioners to keep up with the technical and system-level advances. A systematic meta-study on health care applications of distributed ledgers is needed to provide a structured overview (Agbo et al., 2019).

The digital solution proposed here, still notably a theoretical contribution rather than an application with results at this stage, nevertheless aims to point out the following advantages compared with current paper-based practices:

- Efficient and effective storage of WIC form data via a blockchain digital platform (instead of paper-based form),
- Standardized collection of consent, including preparation of WIC declarations by study coordinators, as well as assessment of WIC declarations templates, involving ethics committees throughout the approval process,
- Management process oversight (workflow of WIC form) and documentation of compliance with all necessary measures (including timestamps),
- Simple digital verification and change management (up-to-date signatures, duty to provide information as, for example, in the context of the GDPR, implementing the "right to forget" at the request of a patient),
- Easy to obtain WIC declarations for the use of data in further studies,
- Operational implementation of study-specific consent management requirements (for example, selection of researchers with whom only certain data is shared),
- Consistent end-to-end (E2E) provenance of data and consent for machine learning applications (for example, a data scientist can digitally check which data may be used for what, without compromising user data integrity),
- Ensuring reciprocity (for example, patients can be contacted anonymously), to inform subjects about the study results at the end of the study,
- Transparency regarding the origin of data in end-user applications.

2.2 Value Network: Stakeholder Network and Unmet Stakeholder Needs

Another step of our structured approach was to define the value network for our use case, and thus to analyse the unmet needs of the stakeholder network involved or impacted by the written consent process of a clinical study (Suman, 2018). Research participants, researchers, and research coordinators form the core of the stakeholder network. Clinics, pharma industry, health insurance companies, regulatory bodies, and many more form the additional elements of the stakeholder network.

Paper-based consent forms have many shortcomings that have led to mistakes in clinical studies. The written consent process must ensure that all stakeholders of a clinical study secure the prospective research participant's ethical and legal right to self-determination. According to the different stakeholder interests and roles involved, the aim is to ensure that all stakeholders: 1) understand concepts associated with voluntary participation, the option to withdraw participation or get information about unforeseen, additional but critical findings for participants, and 2) are assisted and supported during the entire clinical study, in the complex decision-making process that may have many options.

Exemplary for this case, we assume that the study's lead physician acts as an aggregator of the sensitive data and thus represents the 'single point of failure'. Several problems arise in the further processing of data collected in a clinical study:

- It is often unclear, non-GDPR-conform, further use of the data with often unclear, limited application purpose,
- The data processor (for example, data scientist) is usually not aware of the details of the consents or does not have access to them,
- There is no use of the data for other purposes, which go beyond the originally defined one(s), for example, if follow-up questions arise from the research work, new data would theoretically have to be collected or the study participants would have to be asked ex-post,
- There is no practical or feasible way of changing consent, neither if the study participant wishes to extend, limit or cancel their consent, nor if the study

Blockchain-enabled Clinical Study Consent Management

Hans H. Jung and Franz M.J. Pfister

organizer wishes to apply for a consent change (for example, change of purpose),
- There may be complete lack of transparency of the consent's contents, such that the information chain breaks off in most cases after the study's coordinated data has been handed over to data processors.

Complete digital documentation of provenance and consent up to the deployment of AI solutions would be desirable. The application of blockchain technology generates an opportunity to overcome the unmet needs mentioned exemplary for a paper-based process of written consent.

2.3 Value Proposition and Prototype Options

The blockchain approach presented here aims to implement simple and secure management of sensitive written informed consent forms for clinical studies. Currently, the signed forms are usually only available in paper form; accordingly, the management of changes is time-consuming and limited, often even not possible. The proposal provides transaction logging on the blockchain to be based on e.g. Ocean Protocol (Ocean Protocol, 2019) and for information to be implemented in decentralized database systems, for example, BigChainDB, see Figure 2 for details.

For example, a change (for example, extending for participation in a further study) or even lifting of the WIC, as required by the laws, is currently associated with large manual expenditure (for example, in terms of identifying and obtaining stored paper consent forms, and later adopting changes, upon patient's verifiable re-consent).

In the future, we believe that the complex data flow and change management of a clinical trial will be able to be tracked using a blockchain system, and thereby much more easily accessed digitally, than it is today still mostly using paper. The core digital functionality, called 'smart contracts', is thus being investigated for how they can contribute to clinical trial events, by executing pre-defined service execution agreements (SEA) (Nugent 2016). From a global perspective, approaches such as the one presented here with a blockchain backend, should be able to help with reliability, safety, and transparency, and mark a consistent step towards greater reproducibility in the system, for which all parties are calling.

2.4 Potential Digital Business Models

Digital technologies offer the opportunity to synchronize information flow and value creation across all participants of a complex stakeholder network through the application of contemporary digital business models (Jung & Kraft, 2017). The conclusion is simple: instead of building many proprietary networks to track and/or manage written consent (or other elements of a clinical study), the information bottlenecks can be significantly reduced by applying a social machine that orchestrates a standardized (decentralized) digital infrastructure.

Digital business models provide a basis for organizing contracting, ordering, invoicing, or payment that are aimed at driving data accessibility to scale. This means that digital solutions not only strive to reduce the current costs of data gathering, storing, management and security, but also to increase benefits across the ecosystem through new digital business models for cross-network data access, which is permissioned to legitimate stakeholders. In addition, for our particular use case, there is a chance to leverage potential benefits of a distributed network without a single centre, by opening up additional markets for industry collaboration based on standardized consent management for clinical trials, complete with data sharing, network report, and analysis (Engels et al., 2017).

Platform companies are companies that offer digital services based on IoT technologies that are built with data-driven business models. It is also such an applied basis that we use to describe a blockchain-based solution for WICs in this paper.

Blockchain-Based Solution

2.5 System Architecture

Being digitally empowered fundamentally changes the way companies and organizations design and manage their business models and processes (Jung & Kraft, 2017). The proposed blockchain-based healthcare solution, in the following named D-CSCM (Decentralized Clinical Study Consent Management), contains a functional overview to:

- create and manage consent documents,
- store consent documents in a decentralized way,
- log all views and changes of the database entries "on-chain" (incl. modification of consent documents).

All of these steps are enabled by a user-friendly frontend application, where consent documents are created to

Blockchain-enabled Clinical Study Consent Management

Hans H. Jung and Franz M.J. Pfister

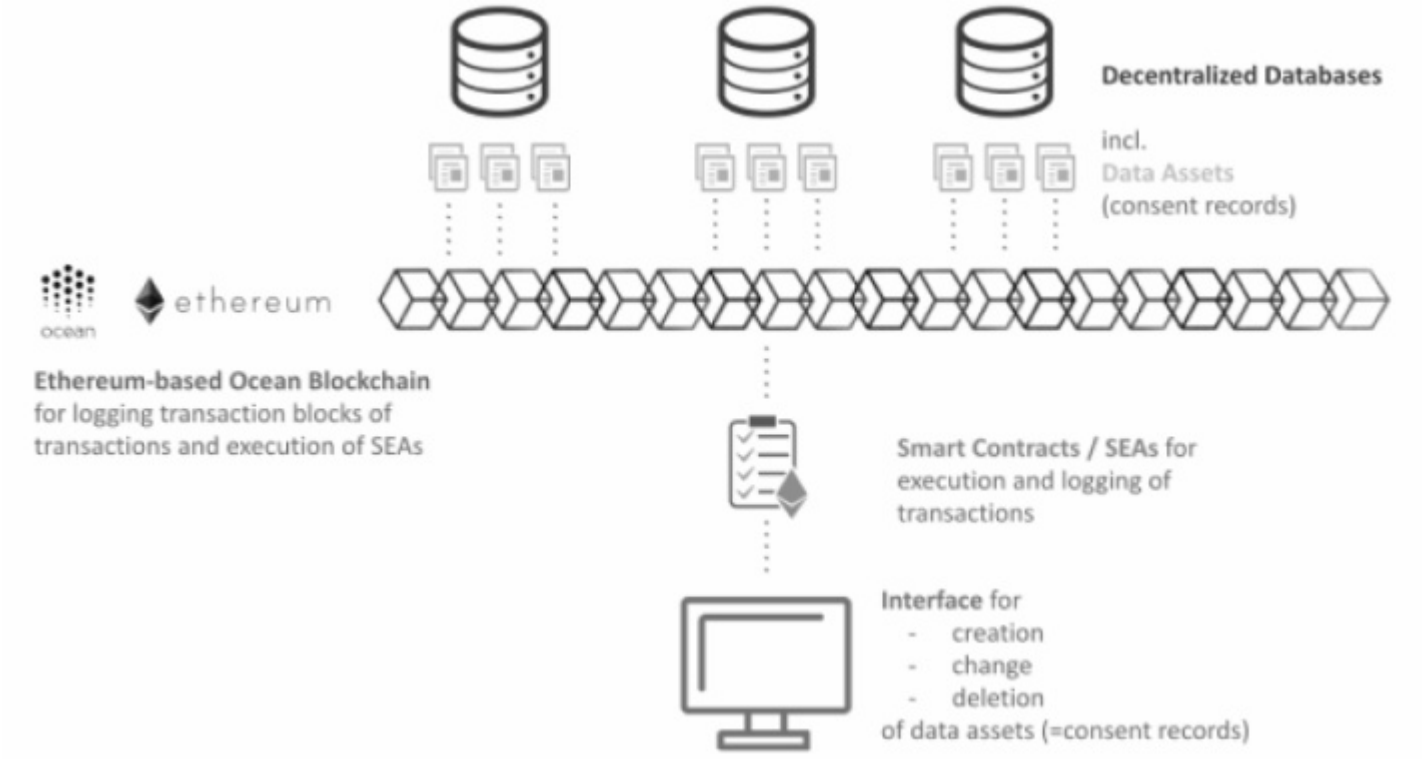

Figure 2. System architecture of the D-CSCM

follow consent templates. The latter are treated as data assets, whose transactions are handled by smart contracts. For technical implementation, the solution is designed to be built on top of the Ocean Protocol framework, which provides basic platform functionality, as well as easy interfaces to make the solution integrable with or together into other (decentralized) system frameworks. Therefore, we designed the D-CSCM to set a new digital ground for associated services, such as data provenance services, training dataset retrieval services, and others.

Ocean Protocol is a decentralized data exchange protocol that connects data providers and consumers, and allows data to be shared, while guaranteeing traceability, transparency, and establishing trust based on reputation and contribution for all stakeholders involved. It enables data owners to give value to and have control over their own data, yet without being locked-in to any single marketplace, beyond the ledger community for local WICs. Ocean Protocol provides a data-sharing framework and an ecosystem for data and related services, which can drive the WIC distributed ledger blockchain.

In the D-CSCM, we treat consent documents as a data asset (DA). The data asset contains (public) meta-information (which may not contain personally identifiable information [PII]) and (private) content information (which is stored in multiple data centres, containing pseudonymized PII). Meta-information, for instance, can include the DID (Decentralized Identifier) of the creator of the data asset, linked data assets, etc.

At the core of Ocean Protocol are Service Execution Agreements (SEA). SEAs are smart contracts that help data and service owners control how their data is being used. The SEA of the proposed framework includes functions for creating, sharing, changing, and deleting DAs. A marketplace framework is used for end-user interaction to create, modify, and delete database entries. All changes are logged “on-chain”.

The system architecture is outlined in Figure 2.

2.6 Digital Mockup and Prototype

The solution proposed in this paper primarily functions as a digital storage and management method, in contrast to the current analog solution. The documents can be stored in a decentralized way (that is, in multiple computers or data centres), thus ensuring data privacy protection, with access granted as part of a distributed

Blockchain-enabled Clinical Study Consent Management

Hans H. Jung and Franz M.J. Pfister

ledger network, which provides protection against loss or destruction of transaction documentation. A technical implementation that leverages blockchain technology offers additional protection in terms of creating an immutable archive of records. The so-called 'block' entries of data constitute part of a growing list of records, which using blockchain as a social machine logs every access, as well as every change of entries visible for all permissioned network participants. Data security according to the GDPR can thus, again we caution, at least in theory, be established by all instances in such a distributed, decentralized digital system.

The digital documentation is made secure with encryption and permission control ("detailed access control"), and thus can be trusted by patients, as well as by study organizers and data scientist. A change in consent (restrictions, withdrawal of consent) can be implemented by the corresponding design of smart contracts.

With blockchain systems, the ground-breaking innovation is that there is no longer a single point of failure over distributed peer-to-peer networks. Thus, the greatest possible network failure security and "fault tolerance" can be achieved. This is an essential requirement in the context of sensitive private patient data that cannot be reproduced.

Blockchain distributed ledger technologies have the potential to radically change business processes and models, even making new ones possible in the first place. Blockchain platforms allow many participants to be connected in a digital network, and for their interactions and processes to be mapped in a way that is extremely difficult, on a mathematical-informational-computing level, to manipulate. An essential difference with existing solutions is that each participant remains in control of their own data.

Instead of supporting a single transaction between a participant and an organizer of a clinical study, a distributed ledger system will enable the creation of a platform business model that includes consent provision and registration, consent management and verification, as well as E2E, P2P data sharing (Rantos et al., 2019). This approach aims to leverage informed

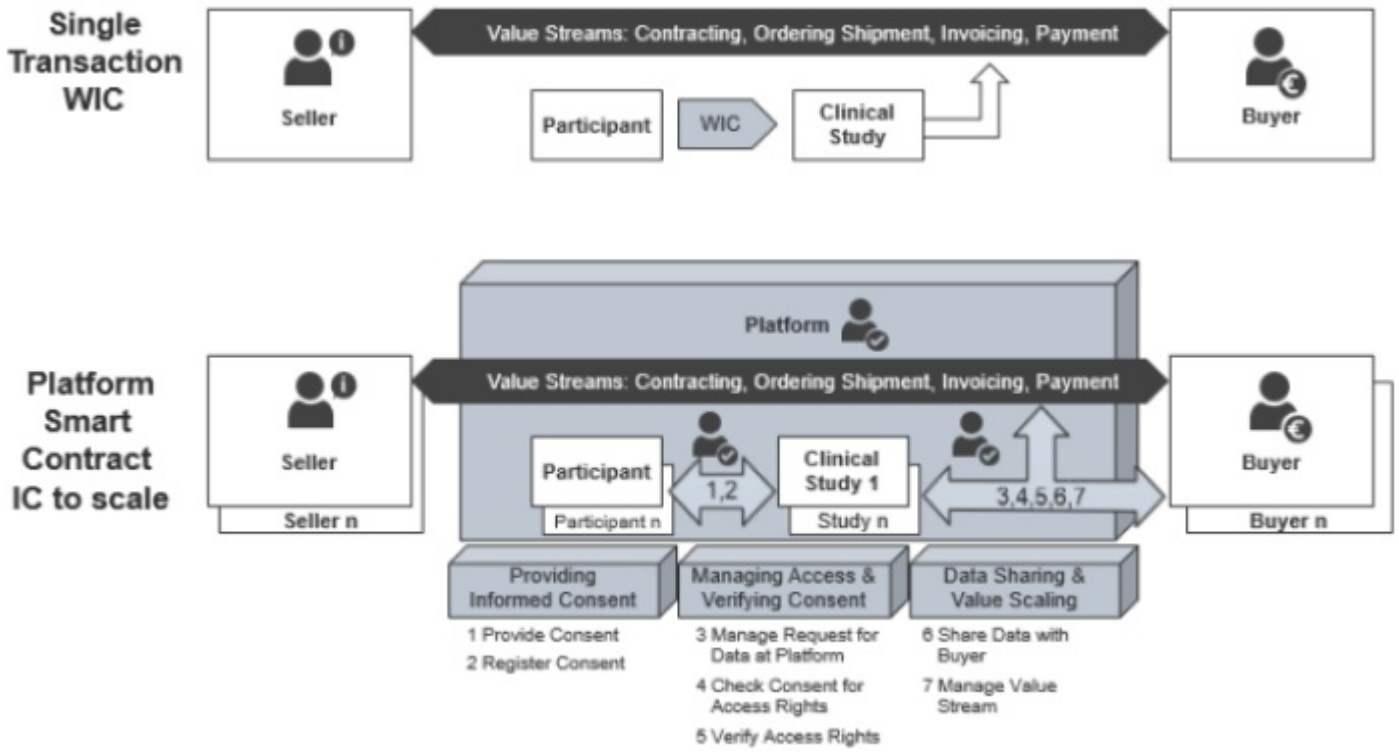

Figure 3. From 'Single Transaction WIC' vs. Platform for Smart Contract Informed Consent (SCIC), built to scale

Blockchain-enabled Clinical Study Consent Management

Hans H. Jung and Franz M.J. Pfister

consent from being a process result, to becoming a process enabler, and even into a multiple business and health value proposition (EBA, 2018). Figure 3 compares the current WIC practice with a smart contract platform incorporating blockchain technology.

Digital consent management is mission-critical for clinical studies in order to prepare them for major challenges. It provides one of the main keys to leveraging data-acquisition-as-a-service business models in healthcare. Regulations in the market so far have aimed at putting individuals in the driver seat to gain control over their personal or private data. Digital consent management thus needs to ensure the user's right to provide re-consent, or to change their consent, at anytime in the process, in order to allow legitimate parties access to clinical information that uses corresponding services.

To make it compliant to GDPR and future regulatory governance models currently in discussion like Artificial Intelligence Ethics (Die Bundesregierung, 2018; European Commission, 2018), it is necessary to organize the platform either with existing trusted parties in a clinical stakeholder system (see part 2.2 of this paper), or by using a neutral external platform provider, such as suggested above in Ocean Protocol.

The application of AI in clinical studies (Jiang et al., 2017; Prevedello et al., 2018) provides a valid scenario for smart contract informed consent (SCIC). We believe that the increasing availability of health data, together with the enhanced performance of AI tools leveraging deep learning algorithms, will trigger a paradigm shift both in theory and practise for clinical studies. This situation thus makes AI ethics into a priority for developing a digital platform using SCIC, and the need for establishing AI ethical codes and guidelines that are crucial success factors in this project more pressing. Principles like transparency, accountability, human autonomy, and wellbeing, as well as beneficence, need to be applied in new healthcare applications.

4. Challenges and Limitations

The authors are well aware of and sensitive to some of the associated challenges and limitations in the proposed D-CSCM. One issue is agreeing to a definition of "smart contracts" in such a way that all stakeholders deem them as being appropriate. Whereas resistance from stakeholders might lead to a major bottleneck, this could nevertheless be solved by diverse expert groups and community or network leaders working together.

Storing data associated with patient data on a public blockchain often raises major privacy concerns, by definition. However, it needs noting that the consent information patients provide, and the clinical data itself, won't be stored on the blockchain. Rather it is stored 'off-chain' in decentralized databases. The blockchain simply stores the encrypted proof of a transaction, that is, to confirm such consent action has taken place. Only through the valid execution of a smart contract, to which users will have a private access key, can the link between the actual consent and clinical data be revealed. The method of storing data in a decentralized way, serves to strengthen the data security properties of the proposed solution.

Another challenge is associated with future access to consent already given by a patient. This requires a digital identity service (on top of a user interface), that links the real identity of a person to their consent information. Whatever technical solution is proposed for this might introduce a data privacy risk. Therefore, the mechanism needs to be discussed, along with which entity will be entitled and responsible to host such a digital identity service (which might be a centralized, trusted party). In addition, part of the consent template should either cover the aspect that links consent to a real person, either as a prerequisite for future consent modifications, or to restrict future consent modifications.

A technical limitation of the proposed solution might be the hosting of nodes that run the decentralized network, especially in the early phases. This can be overcome as a community effort by incentivizing various stakeholders to provide network capacity for the benefit of the entire ecosystem.

5. Conclusion and Outlook

Based on a digital transformation approach, the authors have proposed a new digital solution for WIC storage and management. We demonstrate how blockchain is technically applicable for this healthcare use case. We believe it can be implemented to allow WIC data that is managed in a more transparent and fail-safe manner, via P2P networks, through decentralized storage with

Blockchain-enabled Clinical Study Consent Management

Hans H. Jung and Franz M.J. Pfister

permission validation. This approach in principle would eliminate much of the overall need for trust involved in WIC processing, which is usually created by intermediaries in use cases with multiple and not necessarily known actors. By eliminating the less productive or efficient intermediaries, we believe a level of higher efficiency in terms of time and costs can be achieved.

After presenting a basic classification of the technology and showing current developments, we laid clear foundations for the use case 'WIC for clinical studies'. The research applied several frameworks to define a basic understanding of the data-based business model and the functionality of blockchain technology. We therefore propose building, testing and implementing this system for patients and scientists, through incremental development with local clinics and already existing patient networks. Based on this, we plan to create a proof of concept and to test the strengths and weaknesses of a blockchain-based WIC platform, in order to evaluate its potential, setting a foundation for ethical and scalable health AI applications.

References

Aerztekammer. 2019. *Landesärztekammer Baden-Württemberg* (German). Ethik-Kommission. https://www.aerztekammer-bw.de/10aerzte/05kammern/10laekbw/10service/60ethikkommission/, accessed April 2019.

Agbo, CC, Mahmoud, QH, Eklund, JM. 2019. B*lockchain Technology in Healthcare: A Systematic Review.* Apr 4. Accessed February 2020: doi: 10.3390/healthcare.7020056.

Antes, G., Dreier, G., Hasselblatt, H. 2009. (German). *Bundesgesundheitsblatt*. 52: 459. Accessed May 2019: https://link.springer.com/article/10.1007%2Fs00103-009-0832-6.

Benchoufi, M., Porcher, R., Ravaud, P. 2018. Blockchain protocols in clinical trials: Transparency and traceability of consent. *F1000Res.* 2018;6:66. Feb 1. Accessed May 2019: doi: 10.12688/f1000research.10531.5.

Borioli, GS., Couturier, J. 2018. How blockchain technology can improve the outcome of clinical trials. *British Journal of Healthcare Management*, 24:3: 165-162.

Choudhury, O., Sarker, H., Rudolph, N., Foreman, M., Fay, N., Dhuliawala, M., Sylla, I., Fairoza, N., Das, A. Enforcing Human Subject Regulations using Blockchain and Smart Contracts. In: *Blockchain in Healthcare Today*, 10. doi: 10.30953/bhty.v1.10.

ClinincalTrials. 2019. *Trends, Charts, Maps.* Accessed, May 2019: https://clinicaltrials.gov/ct2/resources/trends

Die Bundesregierung. 2018. *Strategie Künstliche Intelligenz der Bundesregierung* (German). November. Accessed April 2019: https://www.bmbf.de/files/Natioale_KI-Strategie.pdf

DIMDI. 2019. (German) *Deutsches Institut für Medizinische Dokumentation und Information*. Accessed April 2019: https://www.dimdi.de/dynamic/de/startseite

Echterhoff, B., Gausemeier, J., Koldewey, C., Mittag T, Schneider M, Seif H. (German). Geschäftsmodelle für Industrie 4.0 - Digitalisierung als große Chance für zukünftigen Unternehmenserfolg. In Jung HH., Kraft P. (Editors), *Digital vernetzt. Transformation der Wertschöpfung: Szenarien, Optionen und Erfolgsmodelle für smarte Geschäftsmodelle, Produkte und Services*. Hanser: 35-56.

European Bank Association (EBA). 2018. Thought Leadership: B2B Data Sharing: Digital Consent Management as a Driver for Data Opportunities. *EBA Open Bank Working Group*, Paris, Accessed April 2019: https://www.thepaypers.com/payments-general/eba-covers-b2b-data-sharing-in-its-latest-open-banking-research/773504-27

Blockchain-enabled Clinical Study Consent Management

Hans H. Jung and Franz M.J. Pfister

European Medicines Agency. 2019. *Good Clinical Practice (GDP)*. Accessed April 2019: https://www.ema.europa.eu/en/human-regulatory/research-development/compliance/good-clinical-practice

Engels, G., Plass, C., Rammig, F.J. (German). *Acatech DISKUSSION: IT-Plattformen für die Smart Service Welt, Verständnis und Handlungsfelder.* Munich, Accessed May 2019: https://www.acatech.de/wp-content/uploads/2018/03/IT-Plattformen_DISKUSSION_WEB.pdf

European Commission. 2018. *Ethics guidelines for trustworthy AI*. Accessed May 2019: https://ec.europa.eu/digital-single-market/en/news/draft-ethics-guidelines-trustworthy-ai

Jiang, F., Jiang, Y., Zhi, H. 2017. *Artificial intelligence in healthcare: past, present and future Stroke and Vascular Neurology*. doi: 10.1136/svn-2017-000101, Accessed May 2019: https://svn.bmj.com/content/svnbmj/2/4/230.full.pdf

Jung, H.H., Kraft, P. 2017. Introduction. In Jung HH., Kraft P. (Editors) *Digital vernetzt. Transformation der Wertschöpfung: Szenarien, Optionen und Erfolgsmodelle für smarte Geschäftsmodelle, Produkte und Services*. Hanser: VII-X.

Nakamoto, Satoshi. 2008. *Bitcoin: A Peer-to-Peer Electronic Cash System*. Accessed February 2020: https://bitcoin.org/bitcoin.pdf

Nijhawan, L.P., Janodia, M.D., Muddukrishna, B.S. 2013. Informed consent: Issues and challenges. *J Adv Pharm Technol Res.,* 4(3): 134–140. doi: 10.4103/2231-4040.116779. Accessed May 2019: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3777303/

Nugent, T, Upton, D, and Cimpoesu, M. Improving data transparency in clinical trials using blockchain smart contracts. *F1000Research*, 5: 2541. Accessed December 2019: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5357027.1/

Oceanprotocol. 2019. *A Decentralized Data Exchange Protocol to Unlock Data for AI*. Accessed May 2019: https://oceanprotocol.com/

Omar, A., Bhuiyan, M.Z.A., Basu, A., Kiyomoto, S., Rahman, M.S. 2019. Privacy-friendly platform for healthcare data in cloud based on blockchain environment. *Future Gener. Comput. Syst.,* 95: 511–521.

Osipenko, L. 2019. Blockchain's potential to improve clinical trials. *BMJ* (Clinical Research ed.). Oct; 367: l5561. dOI: 10.1136/bmj.l5561.

Purcaru, D., Preda, A., Popa, D., Moga, M.A., Rogozea, L. 2014. Informed Consent: How Much Awareness Is There? *PLoS ONE,* 9(10): e110139. Accessed May 2019: https://doi.org/10.1371/journal.pone.0110139,

Prevedello, L.M., Erdal, B.S., Ryu, J.L., Little, K.J., Demirer, M., Qian, S., White, R.D. 2018. Automated Critical Test Findings Identification and Online Notification System Using Artificial Intelligence in Imaging. *Radiology,* 285:3, 923-931. https://pubs.rsna.org/doi/full/10.1148/radiol.2017162664, accessed in May 2019.

Rantos, K., Drosatos, G., Demertzis, K., Ilioudis, C., Papanikolaou, A., Kritsas, A. 2019. ADvoCATE: A Consent Management Platform for Personal Data Processing in the IoT Using Blockchain Technology. In: Lanet JL., Toma C. (eds) *Innovative Security Solutions for Information Technology and Communications*. SECITC 2018. Lecture Notes in Computer Science, vol 11359. Springer, Cham. Accessed May 2019: https://link.springer.com/chapter/10.1007/978-3-030-12942-2_23

Sandstrom, G. 2017b. *Enter Blockchain: The Non-Evolutionary Recovery of Genesis in Contemporary Discussions of Innovation and Emerging Technologies*. Accessed February 2020: https://medium.com/@gregory.sandstrom/enter-blockchain-the-non-evolutionary-recovery-of-genesis-in-contemporary-discussions-of-96ae135413a6

Sandstrom, G. 2017a. Who Would Live in a Blockchain Society? The Rise of Cryptographically-Enabled Ledger Communities. *Social Epistemology Review and Reply Collective*, 6, no. 5: 27-41. Accessed February 2020: https://social-epistemology.com/2017/05/17/who-would-live-in-a-blockchain-society-the-rise-of-cryptographically-enabled-ledger-communities-gregory-sandstrom/

Schacht S., Lanquillon, C. 2019. (German) *Blockchain und maschinelles Lernen*. Springer.

Suman, A., Chaudhary, N., Jabalia, N. 2018. Role of Bioinformatics in Clinical Trials: An Overview. *National Conference on Innovative Research in Agriculture, Food Science, Forestry, Horticulture, Aquaculture, Animal Sciences, Biodiversity, Environmental Engineering and Climate Change*. AFHABEC-2015: 125-128. Accessed May 2019: https://www.researchgate.net/profile/Nidhee_Chaudhary/publication/304461151_Role_of_Bioinformatics_in_Clinical_Trials_An_overview/links/5a4e50c20f7e9b234d9d07ba/Role-of-Bioinformatics-in-Clinical-Trials-An-overview.pdf

Synnot, A., Ryan, R., Prictor, M., Fetherstonhaugh, D., Parker, B. 2016. Audio visual presentation of information for informed consent for participation in clinical trials. *Cochrane Database of Systematic Reviews*, 2014, Issue 5. Art. No.: CD003717. doi: 10.1002/14651858.CD003717.pub3., Accessed May 2019: https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD003717.pub3/

Blockchain-enabled Clinical Study Consent Management

Hans H. Jung and Franz M.J. Pfister

Tait, A.R., Voepel-Lewis, T. 2015. Digital Multimedia: A New Approach for Informed Consent? *JAMA*, 313(5): 463-464. doi: 10.1001/jama.2014.17122 Accessed May 2019: https://jamanetwork.com/journals/jama/article-abstract/2107798

UNITY. 2019. *Geschäftsmodelle*. Accessed April 2019: https://www.unity.de/de/leistungen/digitale-transformation-industrie-4-0/geschaeftsmodelle-fuer-industrie-40/

Wenlong L. 2018. A tale of two rights: exploring the potential conflict between right to data portability and right to be forgotten under the General Data Protection Regulation. *International Data Privacy Law*, Volume 8, Issue 4, November: 309-317 Accessed April 2019: https://doi.org/10.1093/idpl/ipy007

About the Authors

Hans H. Jung is teaching on international marketing, digital business models and digital transformation courses as a professor at the Munich Business School. As principal, he heads the digital customer experience community at UNITY AG, a leading Management Consulting & Innovation Company. His more than 100 clients include companies from agriculture, automotive, energy, consumer goods, mobility, pharmaceutical and process industries, sports, among others.

Franz MJ Pfister is an entrepreneur, medical doctor, and data scientist and is recognized as a leading expert at the intersection of artificial intelligence, data, digitization, and healthcare. His academic career includes medical studies at the Ludwig Maximilian University of Munich and the Harvard Medical School with a medical doctorate in neuroscience. He holds an MBA from Munich Business School and earned a Master's degree in Data Science at the LMU Munich. Franz Pfister is currently leading multiple initiatives and is building up companies in the field of Health AI, developing next-generation diagnostic solutions to improve patient care and enable personalized medicine.

Citation: Jung, H.H., Pfister, F.M.J. 2020. Blockchain-enabled Clinical Study Consent Management. *Technology Innovation Management Review*, 10(2): 14-24. http://doi.org/10.22215/timreview/1325

Keywords: Clinical Study, Written Informed Consent, Platform Business Model, Blockchain, Health Artificial Intelligence (AI), AI Ethics.

The Ethical Dimensions of Public Opinion on Smart Robots

Mika Westerlund

> *"I suppose your father lost his job to a robot. I don't know, maybe you would have simply banned the Internet to keep the libraries open."*
>
> Lawrence Robertson
> I, Robot (2004)

This article investigates public opinion about smart robots, with special focus on the ethical dimension. In so doing, the study reviews relevant literature and analyzes data from the comments sections of four publically available online news articles on smart robots. Findings from the content analysis of investigated comments suggest that public opinion about smart robots remains fairly negative, and that public discussion is focused on potentially negative social and economic impacts of smart robots on society, as well as various liability issues. In particular, many comments were what can only be called "apocalyptical", suggesting that the rise of smart robots is a threat to the very existence of human beings, and that the replacement of human labour by smart robots will lead to deepening the socio-economic gap, and concentrating power and wealth in the hands of even fewer people. Further, public discussion seems to pay little attention to the debate on whether robots should have "rights", or on the increasing environmental effects of the growth in robotics. This study contributes to the extant literature on "roboethics", by suggesting a dendrogram approach to illustrate themes based on a qualitative content analysis. It suggests that smart robot manufacturers should ensure better transparency and inclusion in their robotics design processes to foster public adoption of robots.

Introduction

At present, we are facing a "robotic demographic explosion". The number of robots at work and home is rapidly increasing (Lichocki et al., 2011). Tsafestas (2018) adds a note of foresight, that not only will there be many types of robots (for example, industrial, service, social, assistive, home), but also that robots will become more and more involved in human life in the near future. In particular, "smart robots" are expected to achieve widespread diffusion in society (Torresen, 2018). As such, it is best for us to be prepared, by starting to understand the effects such robots will have on society and our personal lives, so that we may, as Marshall McLuhan noted, "think things out before we put them out" (1964).

Using the definition by Westerlund (2020), smart robots are "autonomous artificial intelligence (AI)-driven systems that can collaborate with humans and are capable to learn from their operating environment, previous experience and human behaviour in human-machine interaction (HMI) in order to improve their performance and capabilities." That said, it is becoming increasingly difficult to categorize smart robots by their purpose, as new smart robots are now built for multiple purposes (Javahari et al., 2019; Westerlund, 2020). For example, Samsung's "Ballie" is used as a life companion, personal assistant, fitness assistant, robotic pet, and coordinator of a fleet of home robots in a household (Hitti, 2020). Similarly, Trifo's "Lucy" is used as a smart robot vacuum that recognizes rooms by the type of furniture it sees, while also operating as a security system that provides day and night video surveillance (Bradford, 2020).

As smart robots are starting to come equipped with AI and various levels of functional autonomy, HMI thus becomes increasingly complex, and raises a host of ethical questions (Bogue, 2014a). Robotics applications must meet numerous legal and social requirements before they will be accepted by society (Lin et al., 2011; Alsegier, 2016). Thus, Torresen (2018) argues that designers of smart robots should ensure, 1) safety (mechanisms to control a robot's autonomy), 2) security (preventing inappropriate use of a robot), 3) traceability (a "black box" records a robot's behaviour), 4) identifiability (a robot's identification number), and 5)

The Ethical Dimensions of Public Opinion on Smart Robots

Mika Westerlund

privacy (protection of data that the robot saves). Nonetheless, although public opinion on robots may be positive, there is anxiety about robots replacing humans in the labour force (Gnambs, 2019; Tuisku et al., 2019). Other concerns include, for example, technology addiction, robotic effects on human relations, the risk of a dystopian future, the lack of control in robotics development, and in general the difficult category of ethics (Cave et al., 2019; Operto, 2019; Torresen, 2018). Opinions about killer robots and sex robots are particularly polarized (Horowitz, 2016; Javaheri et al., 2019). Hence, the current need is obvious for more systematic research on the public perception of smart robots involving ethics (Westerlund, 2020).

The objective of this article is to investigate public opinion about smart robots, giving special attention to the ethical dimension. In so doing, the study reviews the main issues in what is now called "roboethics", involving public opinion about robots, as well as further elaborates an ethical framework for smart robots, as introduced by Westerlund (2020). The study follows this framework by using a thematic content analysis of a data set consisting of 320 publicly available readers' comments, coming from the comments sections of four freely available online news articles about smart robots. The purpose of the content analysis was to categorize public opinion about smart robots using a framework with four different ethical perspectives. In so doing, the study reveals that the majority of comments focused on the current or coming future social and economic impacts of robots on our society, emphasize the negative consequences. The results even suggest that of four ethical perspectives, the one in particular that views "smart robots as ethical impact-makers in society" is characterized by negative perceptions, and even apocalyptical views about smart robots taking a greater role in human society.

Literature Review

In order to gain a better understanding about ethical dimensions in the context of smart robots, this study reviews previous literature on this topic. It includes a conceptual framework used for an empirical analysis in the present study. As well, the study briefly addresses the state of public opinion about smart robots.

Ethical perspectives to smart robots

The field of robotics applications is broadening in accordance with scientific and technological achievements across various research domains (Veruggio & Operto, 2006). In particular, recent advances in AI and deep learning have had a major impact on the development of smart robots (Torresen, 2018). As a result of scientific and technological progress in these fields, it is increasingly difficult for manufacturers to estimate the state of awareness and knowledge people have about smart robots (Dekoulis, 2017). Further, Müller and Bostrom (2016) argue that autonomous systems will likely progress to a kind of "superintelligence", containing machine "intellect" that exceeds the cognitive performance of human beings in a few decades.

Veruggio and Operto (2008) take this a step further by suggesting that eventually machines may exceed humanity not only in intellectual dimensions, but also in moral dimensions, thus resulting in super-smart robots with a rational mind and unshaken morality. That said, scholars, novelists, and filmmakers have all considered the possibility that autonomous systems such as smart robots may turn out to become evil (Beltramini, 2019). In response to this danger, some people have thus suggested that the safest way might be to prevent robots from ever acquiring moral autonomy in their decision making (Iphofen & Kritikos, 2019).

There are many other ethical challenges arising along with robotics, including the future of work (rising unemployment due to robotic automation) and technology risks (loss of human skills due to technological dependence, or destructive robots) (Lin et al., 2011; Torresen, 2018). Further ethical challenges include the humanization of HMI (cognitive and affective bonds toward machines, "the Tamagotchi effect"), anthropomorphization of robots (the illusion that robots have internal states that correspond to emotions they express in words), technology addiction, the effect of robotics on the fair distribution of wealth and power, including a reduction of the socio-technological divide, and equal accessibility to care robots. Likewise important is the environmental impact of robotics technology, including e-waste, disposal of robots at the end of their lifecycle, increased pressure on energy and mining resources, and the rise in the amount of ambient radiofrequency radiation that has been blamed for a decline of honeybees necessary for pollination, agriculture, and certain human health problems (Bertolini & Aiello, 2018; Borenstein & Pearson, 2013; Lin et al., 2011; Tsafestas, 2018; Veruggio & Operto, 2006; Veruggio & Operto, 2008).

The Ethical Dimensions of Public Opinion on Smart Robots

Mika Westerlund

Robots can in various ways potentially cause psychological and social problems, especially in vulnerable populations such as children, older persons, and medical patients (Veruggio et al., 2011). Children may form a bond with robots and perceive them as friends. This may also lure parents to overestimate the capacities of robots, resulting in over-confidence involving robots as caregivers and educators (Steinert, 2014). Thus, especially designers of companion robots or smart toy robots for children and care robots for the elderly, need to consider physical, psychosocial, and cognitive health consequences and side-effects of a robot to a person (Čaić et al., 2018).

Moreover, there are issues regarding the attribution of civil and criminal liability if a smart robot produces damages (Veruggio et al., 2011). Smart robots undoubtedly have the potential to cause damage and financial loss, human injury or loss of life, either intentionally or accidentally (Bogue, 2014b). The first recorded human death by a robot occurred in 1979, when an industrial robot's arm slammed into a Ford Motor Co.'s assembly line worker as he was gathering parts in a storage facility (Kravets, 2010). Thus, it is important to evaluate what limitations and cautions are needed for the development of smart robots, especially due to peoples' increasing dependence on robots, which may lead to significant negative effects on human rights and society in general (Alsegier, 2016).

Westerlund (2020) reviewed previous literature on "roboethics" and, based on the work of Steinert (2014), introduced a framework to identify key ethical perspectives regarding smart robots. "Roboethics" has become an interdisciplinary field that studies the ethical implications and consequences of robotics in society (Tsafestas, 2018). The field aims to motivate moral designs, development, and use of robots for the overall benefit of humanity (Tsafestas, 2018). Thus, "roboethics" investigates social and ethical problems due to effects caused by changes in HMI. This can be defined as ethics that inspires the design, development, and employment of intelligent machines (Veruggio & Operto, 2006).

Taken in this light, Westerlund's (2020) conceptual framework builds on two ethical dimensions, namely the "ethical agency of humans using smart robots" (robots as amoral tools vis-à-vis moral agents), and "robots as objects of moral judgment" (robots as objects of ethical behaviour vis-à-vis the ethical changes in society due to smart robots). Further, Westerlund's (ibid.) framework introduces four ethical perspectives to smart robots: 1) smart robots as amoral and passive tools, 2) smart robots as recipients of ethical behaviour in society, 3) smart robots as moral and active agents, and 4) smart robots as ethical impact-makers in society. Even though these perspectives are non-exclusive and should be considered simultaneously, Westerlund (ibid.) suggests that the framework can be used as a conceptual tool to analyze public opinion about smart robots.

Public opinion of smart robots

Gnambs (2019) proposes that monitoring public opinion about smart robots is important because general attitudes towards smart robots shape peoples' decisions to purchase such robots. Negative attitudes about them might therefore impede the diffusion of smart robots. According to Operto (2019), robotics is often narrated in the public consciousness with myths and legends that have little or no correspondence in reality. However, Javaheri et al. (2019) note that both news media and the general public show overall positive opinion about robots, even though the discussion focus has shifted from industrial robots to smart social and assistive robots. That said, public opinion can be polarized on issues such as increasing automation that yields both positive (workplace assistance) and negative consequences (job loss) in a society (Gnambs, 2019), including sex robots (Javaheri et al., 2019), and "killer robots" (Horowitz, 2016), which tend to raise fierce debate. Operto (2019) states that peoples' attitudes and expectations towards robots are complex, multidimensional, and oftentimes self-contradictory. While people value the growing presence of robots, they also may show or express fears about the spread of robotics in human societies. Cave et al. (2019) found that anxiety about AI and robots is more common than excitement. Further, it is not uncommon for people to feel that they do not have control over AI's development, advances in AI that serve to increase the power of corporations and governments, and that society's technological development determines the progress of its social structure and cultural values. In other words, there appears to be a fairly widespread feeling against technological determinism, or at least concern about it in society today.

Method

This study draws on a content analysis of publicly available data, namely the comments sections of four online news articles about smart robots. These publicly available news articles included one from The Economist (Anonymous, 2014), two from The Guardian

The Ethical Dimensions of Public Opinion on Smart Robots

Mika Westerlund

(Davis, 2013; Devlin, 2016), and one from The New York Times (Haberman, 2016) published in 2013-2016. Consequently, a total of 320 publicly available comments from readers of those four articles were collected from the host news media websites. The articles and their comments sections were found using Google News search, with a combination of "smart robots", "ethics", and "comments" as a search string. In this vein, it was expected that the search results would provide news articles that included a comments section. To be included, chosen articles needed to reflect a relatively neutral tone, and include a minimum of 20 readers' comments to ensure higher quality data. Focusing on news articles related to smart robots from well-known news media companies resulted in four articles that met the criteria. Each of the chosen articles included between 29 and 127 comments.

The comments section is a feature of digital news websites in which the news media companies invite their audience to comment on the content (Wikipedia, 2020). Several previous studies on public perception of robots (for example, Fedock et al., 2018; Melson et al., 2009; Tuisku et al., 2019; Yu, 2020) have made use of publicly available articles, with commentaries or social media comments. Benefits in focusing on comments sections rather than social media data, include, first, that people behind the investigated comments in this study remained anonymous, as they commented on articles either behind a user-generated avatar, or without any screen name as "anonymous". Second, the investigated news article comment sections were perceived as a feasible source of information. This is based on two features, that the articles are moderated in accordance with the host site's legal and community standards, and that their moderators tend to block disruptive comments and comments aiming to derail the discussion and debate (Gardiner et al., 2016). Also, Calabrese and Jenard (2018) note that moving off-topic is less common in news media commentaries, in comparison with user posts on social media platforms such as Facebook, which largely do not produce news content, but rather redistribute it.

According to Yu (2020), analyzing online comments can give valuable insights into how people perceive robotics in society. Following the examples of Fedock et al. (2018), Melson et al. (2009), Tuisku et al. (2019), and Yu (2020), for this study readers' comments were analyzed by means of thematic content analysis, which takes an organized approach to classify textual data. Fedock et al. (2018) emphasize the fact that a written informed consent (WIC) form is not required, as researchers are simply the primary instruments in subjectively interpreting words, phrases, and sentences of publicly available data.

Following the advice of Björling et al. (forthcoming), the collected data for this study were analyzed using a two-step process. First, the researcher used open coding, which aimed at identifying comments deemed relevant for the study's focus, and then segmented them into short, meaningful quotes, as well as encapsulating their theme in single word. As a result, the data set of 320 comments was found to include 117 comments (37 percent) that were relevant for this study, and which expressed a meaningful, coherent and identifiable theme. Second, the researcher considered common themes and outliers in the data, contemplated them against the themes identified in the literature review, and then began a more focused thematic analysis of the data, according to the short quotes organized under common themes. Similar to Fedock et al. (2018), the themes that surfaced from this analysis will be discussed below using rich descriptions.

The results from the content analysis are visualized using a bar graph and a dendrogram, which is a popular method to display hierarchical clustering of similar objects into groups (Henry et al., 2015). Although such visual displays are common in quantitative research (Verdinelli & Scagnoli, 2013), some studies have suggested using them to illustrate thematic qualitative information as well (see for example, Guest & McLellan, 2003; Stokes & Urquhart, 2013). While the data does not need to be originally quantitative, the methods necessitate some kind of data quantification. For example, Melson et al. (2009) used topic counts to present relative coverage of topics in their data. Döring and Poeschl (2019) investigated representations of robots in media, and quantified a number of variables for visualising the results as a dendrogram. Creating a dendrogram requires the researcher to organize themes hierarchically according to research objectives, or in response to a perceived logical relationship among themes (Guest & McLellan, 2003). In the present study, topic occurrences were quantified according to "topic count", and then themes were clustered applying Westerlund's (2020) ethical framework for smart robots to organize the data.

Findings

After organizing short quotes from 117 comments thematically into 11 themes, and labeling each theme in a compact characterizing manner, the number of quotes

The Ethical Dimensions of Public Opinion on Smart Robots

Mika Westerlund

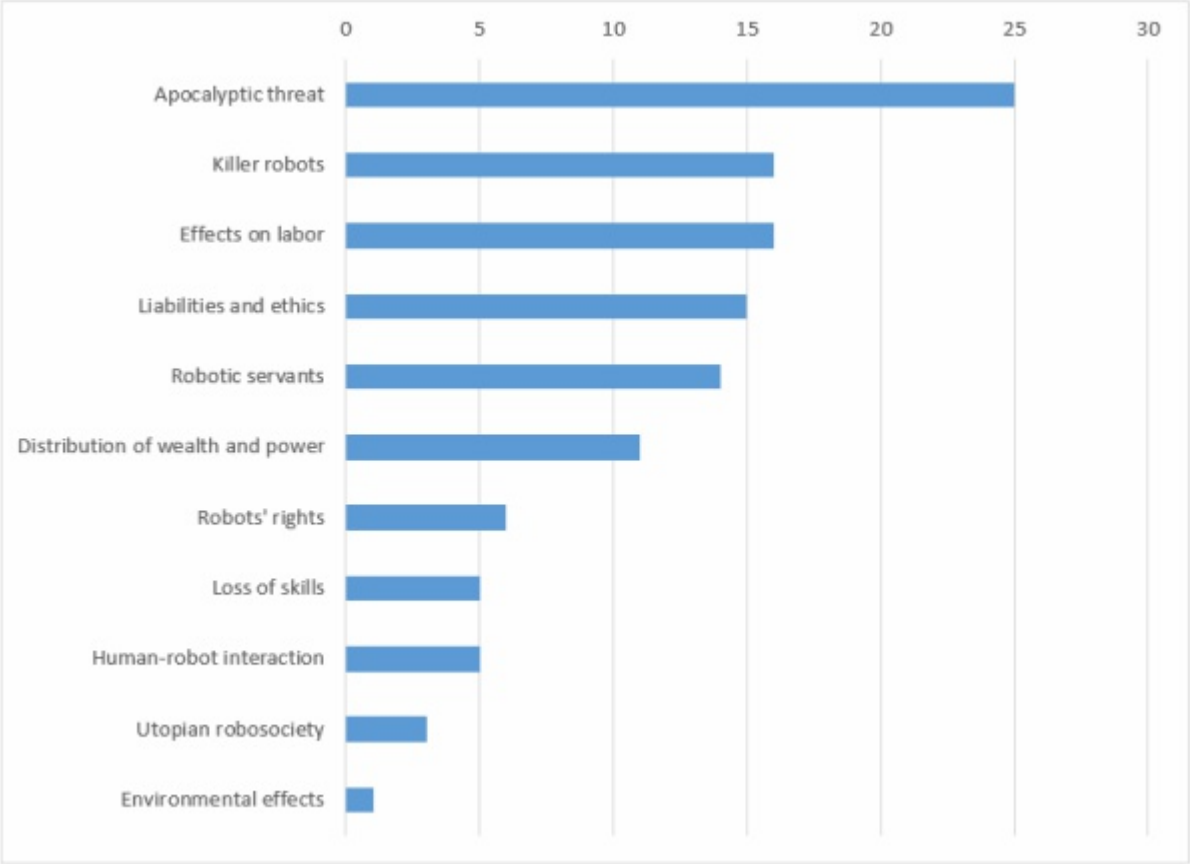

Figure 1. Topic count of comments (n=117)

under each theme was counted. Figure 1 shows a bar graph of main themes, organized in declining order from the largest "topic count" to smallest.

Apocalyptic view

The largest group of comments represented the "apocalyptic view", where machines were seen as coming to take over, enslave, and even eventually extinguish humanity. While the reasons for this are many, the most common given was because future robots will at some point supposedly perceive humans as redundant, or even as a threat. Such apocalyptical views are seen as a consequence of robots learning and becoming increasingly intelligent, on a trajectory that some think will eventually exceed our human intellectual capacity, as well as being far superior physically . As a result, robots will emerge from servants of humans into helpmates, and then from helpmates into our overlords.

Only a few positive comments stated that the danger from robots is not a necessary outcome of their superiority, and instead that humankind will be safe and greatly benefit from robotic technology. They believed this is possible if we ensure that the developmental pathway of robots does not conflict with ours. The majority held the view that human beings as a whole would not have much chance in armed conflict against intelligent machines. Therefore, giving autonomy and rights to robots and AI systems such as Skynet —an intelligent military defense system in Terminator movies — may presage the end of the human race. Some comments added that an intellectually superior species always wins in confrontations with inferior ones; for example, gorillas are inevitably the losers in confrontations with humans beyond sheer physical strength. From this view, it is possible to conclude that, since robots do not share our same human values, they could easily become to us as we are to domestic pets, that is, as masters to another species.

Killer robots

Another major theme in the data was the notion of "killer robots". Many commenters noted that military

The Ethical Dimensions of Public Opinion on Smart Robots

Mika Westerlund

drones and robots are already developed and being used. The introduction of ever more destructive robotic weapons, they believed, is inevitable given the military's role in funding and advancing robotics development. The military's supposed interest in these fighting robots was linked to the fact that autonomous weapons are faster, safer, more effective, and more capable than only human soldiers, and that robots can carry out lethal missions without feelings of guilt or fear. Some commented that accountability for human deaths caused by an autonomous weapon always lies on those who programmed the machine as a weapon. Others pointed out that, similar to any computer technology, weaponized robots with autonomous decision-making capability are prone to "unexplained" errors and malfunctions. The lack of a robot's capacity to reliably tell friend from foe (such as a civilian from a combatant), could lead to unintended and unavoidable deaths and injuries. Thus, an important question is raised about liability, whether or not owners and designers of autonomous fighting robots should be held accountable for killing caused by glitches in technology.

Effects of robotics on labour

Unsurprisingly, the "effects of robotics on labour" was a major theme. Some comments praised robotics as a means for developed economies to fight globalization, and the offshoring of production. Thus, robots can help local sourcing and provide new occupations and better jobs for people. However, again the majority of comments argued negatively, this time that automation is replacing both manual and non-manual workforce and stealing jobs. The argument here was that robots can work 24/7, and have no political power, which combined unquestionably makes them more profitable than even low-wage workers. The concern was that as robots come to displace certain human workers, society as a whole will face upheavals, structural unemployment, and a growing underclass of permanently unemployed. Interestingly, one comment suggested a solution to this problem: the ownership of robots should be limited to co-operatives, which could rent robots out for industrial and commercial use, as well as to individuals in need of robots. The generated revenue stream would then be used to compensate for lost human worker income resulting from the increased automation and job losses due to robots. In short, not all comments involving robotics and the future of work were full of doom and gloom.

Liabilities and ethics

Also, concerns regarding "liabilities and ethics" surfaced in the data. The analyzed comments addressed whether private individuals should be allowed to own a robot at all, and if the owner and/or the vendor of the robot could or should be sued in the event of an accident or injury. Comments also mentioned that everyone would likely try to blame someone else in such a situation. Especially the lack of transparency makes it impossible to know why designers and manufacturers make the decisions they do, and whether or not mistakes by their robots are due to a design fault or something else. That said, the majority of comments focused on the ethics guiding a robot's decision-making process, meaning to say, what "ethics" a robot is itself coded to have. Some comments argued that robots will ultimately demonstrate the same ethics as humans, while others suggested that ethics are always subjective, and that there may be no absolutely applicable ethics. The question thus remains: whose values and ethics should be implied? Another issue was expressed that if a self-learning system emerges and evolves gradually, this would seem necessarily to lead to both unavoidable mistakes and unpredictable consequences. Such a conclusion was reached especially because robots lack essential human qualities such as kindness, compassion, empathy, love, and spirituality, which affect human values and ethics.

Robotic servants

Comments representing the perspective of "robotic servants" were threefold. Some people argued that even intelligent robots are nothing but tools and accessories for human beings to accomplish tasks, and that they are designed to work in structured and customized environments, such as factories, and to perform specific, difficult and sometimes dangerous tasks. They do not have "a mind of their own" with goals or purpose to accomplish anything beyond what they were built for, and thus robots cannot perform truly complex and sensitive tasks, such as taking care of and feeding a baby. Other comments emphasized that robots are artificial workers like household appliances, designed to be slaves that we do not need to feel guilty about. Robots in this perspective are not considered as a threat to human beings unless they start operating outside of our commands. Hence, robots should not be thought of as having emotions or feelings, such as being able to feel happy or enjoy playing a piano. Finally, many comments under this topic argued that AI is actually not "intelligence" at all, but rather something that incomprehensively resembles our understanding of intelligence. Further, the mainstream media has falsely painted a picture of AI as a super-advanced independent

The Ethical Dimensions of Public Opinion on Smart Robots

Mika Westerlund

thinker. The reality is, however, that smart robots do not have real thought or consciousness, and even the most reliable artificially intelligent systems do well only as long as they have masses of reliable data for analysis and calculation.

Distribution of wealth and power

Comments on the possibility of a new "distribution of wealth and power" emerging due to the introduction of smart robots were fairly uniform. As long as technological advances in robotics are made available to everyone, the future is supposed to be bright. However, commenters seemed to lack belief in such a levelling generosity, and deemed instead that only the rich are likely to benefit from robots. The rich will get richer and more powerful, and will only socialize with people of their own class status. Their wealth will be measured by the number of robots they have or "own" as tireless and obedient servants and workers. Meanwhile, the middle class and lower classes will face higher prospects of losing their jobs due to automation, and more and more people will drop into poverty, while only a few rise to the top. Robots will widen not only the socio-economical gap, but also the socio-technical divide. Rich elites will program robots for their benefit and profit, while those people who are unable to handle new robotic technology will be forced to adapt or perish. Although the new wealth created with the help of robots could be used to benefit humanity, the rich elite will instead hoard it, leading to the total triumph of capital and defeat of labour. Such was often the dystopian political version of ethics that commenters voiced in relation to smart robots.

Robots' rights

The theme of focusing on "robots' rights" had the most positive comments. Two comments argued that not only it is inane to develop smart robots to a point where we might have to consider giving them rights, nevertheless, it would still likely take a long time before killing an intelligent machine would be considered equal to murder. Nevertheless, the rest of the comments took the approach that a freethinking robot cannot properly be thought about as a slave. Such an advanced robot should be seen as an independent non-human life form, with rights and responsibilities according to this new "artificial species". Further, along with seeing smart robots as equal in certain ways to human beings, commenters believed we would likewise need to afford them some benefits and protections similar to humans, in terms not yet decided by the courts of law. In addition, one comment mentioned that a thriving economy necessitates consumers with incomes, so it would be better to make robots into consumers as well, just as human beings are, by paying them for their work. This line of thinking opens up countless opportunities for anthropomorphising the future of robots with human-like rights.

Loss of skills

Comments reflecting on the "loss of skills" topic, argued that, as masters to robotic servants, human beings will become lazy, thereby losing the skills of how to cook, clean, drive, and care for our children, the sick, and elderly. Such laziness, based on a naïve trust in technology, leads to a loss of basic skills, where people develop the habit of expecting to be served by smart robots that wander around our houses. This would lead to an ever-increasing technology dependency, with self-evident dangers, because eventually "the lights will go off". In addition, the fact that smart robotic servants and companions will be programmed to make important decisions alongside of, or on behalf of their lazy masters, was seen as risky. Responsibility and blame can become unclear in problem situations, when the decision may actually have been made by a network of intelligent communication that the connected robot was part of, rather than by a robot itself. Moreover, one of the comments argued that having smart robots take over some tasks will not only lead to a human loss of skills, but also to a loss of pleasure. Many people, for example, would still enjoy driving a car in addition to just riding in an autonomous driverless vehicle.

Human-robot interaction

Issues in "human-robot interaction" have for many years in science fiction, and for fewer in industrial and professional practises, included the question of smart robots replacing human relationships, particularly in regard to raising children or taking care of the elderly. The comments emphasized the potential psychological consequences of replacing parenting with robots, and regarding the elderly potentially being confused into believing that a patient care robot actually cares about their feelings. On the other hand, one comment argued that robot companions could provide a great solution to depression from loneliness. At issue here, however, is that robots lack many human qualities, and indeed humans have to adapt their behaviour to make human-machine interaction useful. As a result, while robots are designed and manufactured to behave in some ways like humans, instead humans are nowadays also behaving more and more like machines. Another issue surfacing in comments was potentially inappropriate behaviour

The Ethical Dimensions of Public Opinion on Smart Robots

Mika Westerlund

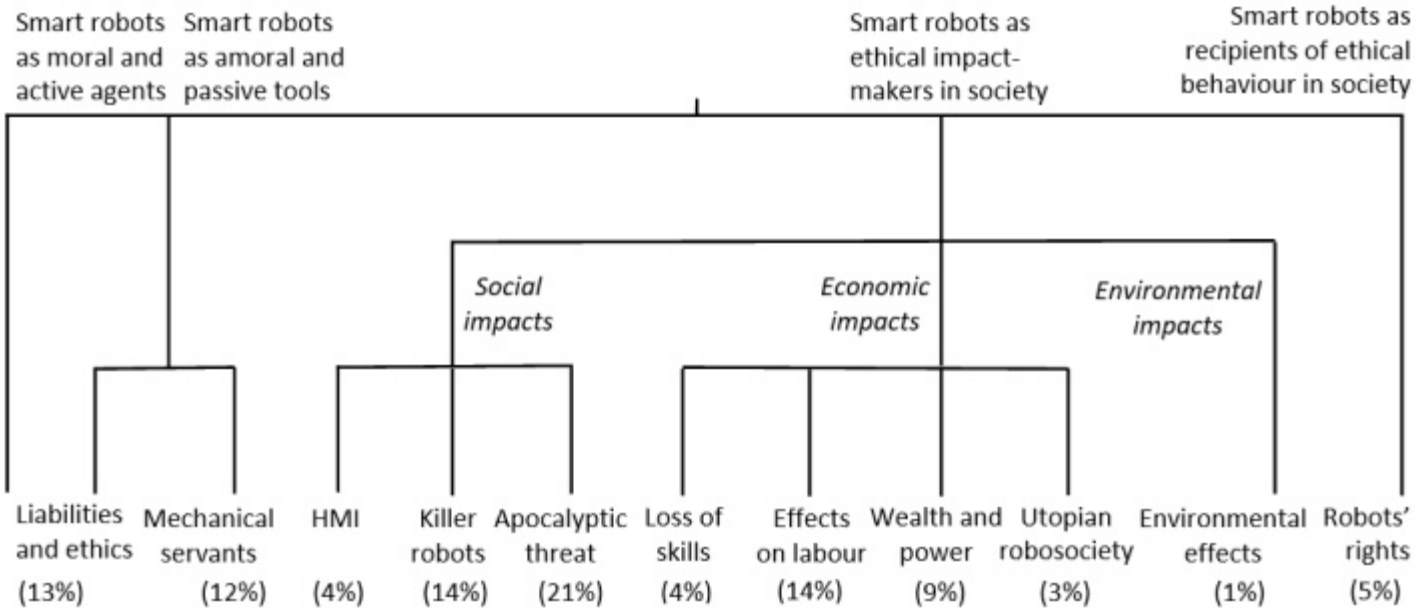

Figure 2. A vertical dendrogram of main themes in comments

by autonomous robots in HMI, including unethical action, such as making racist, sexist, or homophobic remarks. That said, the comments also questioned how a robot can be sexist or racist, unless it was programmed that way. In such a case, how would one punish a robot for such behaviour?

Utopian robosociety and Environmental effects

Finally, a couple of comments addressed the birth of a "utopian robosociety", which would mean a shift to some kind of post-capitalism scenario. These comments were largely political by nature, yet highly positive, arguing that, in the long run, technology typically improves the social and working lives of human beings. However, a concern was also raised that if labour at some point starts to rapidly disappear due to robotics, we would then need to think about how to better distribute the wealth, along with what people would do with their newly freed time. In a utopian robosociety, every human person would in principle have a fairly similar living standard, which is because essential goods such as food would be made and provided to us by robots. This means that the government would need to build automated farms running on solar or nuclear energy, which produce food for everyone. Nevertheless, cheap and ubiquitous robotics technology, with constant new models and improvements looks to become a huge future challenge, in terms of clean disposal, and recycling of robotics materials. These issues were addressed in a comment focusing on the "environmental effects" of robots.

Conceptual clustering of themes

Based on the above discussion, we grouped the themes under four ethical perspectives for smart robots. We adopted a dendrogram approach, which is a popular visual display for illustrating hierarchically clustered information. Hence, we clustered the themes that are conceptually close to each other into groups of themes. Further, following suggestions by Guest and McLellan (2003), themes were clustered by placing the resulted groups under four ethical perspectives, then applying a conceptual ethics framework (Westerlund, 2020). The vertical dendrogram in Figure 2 shows the 11 themes identified in comments as clustered into thematically similar groups. Consequently, these groups are placed under relevant ethical perspectives for smart robots, according to the relative size of each theme in the data.

As a result of clustering, we can see that the notion of "smart robots as ethical impact-makers in society" was the most common ethical perspective in terms of the relative size of themes, representing a total of 70 percent of comments. Further, clustering revealed three different types of impact that people believe smart robots have, or are soon set to have: social, economic, and environmental impacts. Social impacts represented

The Ethical Dimensions of Public Opinion on Smart Robots

Mika Westerlund

altogether 39 percent of the comments, in contrast with economic impacts, which represented a total of 30 percent, and environmental impacts just 1 percent. In total, ethical perspectives discussing "smart robots as recipients of ethical behaviour in society", and as "ethical impact-makers in society" combined to represent 75 percent of comments, whereas ethical perspectives discussing robots either as moral or amoral actors only represented 25 percent. Of note, the theme "liabilities and ethics" surfaced in comments both from the perspectives of "smart robots as moral and active agents", and "smart robots as amoral and passive tools".

Discussion and Conclusion

The study's objective was to investigate public opinion about smart robots, with special focus on the ethical dimension. Performing a thematic content analysis over 320 readers' comments on four publicly available online news articles about smart robots, the study identified 117 relevant comments with 11 themes that surfaced in those comments. After clustering the themes hierarchically into a dendrogram, the study found that the vast majority (70 percent) of comments focused on present and coming future social, economic, and environmental impacts of smart robots. In general, the social impacts were seen as quite apocalyptical. Ever "smarter" robots might lead to the intended or unintended step of trying to destroy humanity. Comments also highlighted the economic impacts centered on robots taking over human jobs, and thereby deepening the socio-economic gap. On the other hand, 25 percent of comments viewed robots as servants to human beings, or addressed liability issues in case a robot malfunctions or demonstrates inappropriate action.

When clustered, the data illustrates a hierarchy of main concerns that revolve around smart robots' social and economic impacts, as well as liability issues. This contributes a small, but important addition to the literature on "roboethics" by presenting a visual display that shows relevant ethical themes and their weighted importance, according to non-guided public discussion on smart robots.

While previous research has suggested that public opinion about robots is generally positive (Gnambs, 2019), the overall tone displayed in this investigation was remarkably negative. There were only a few themes with positive comments. The most positive themes were small, including "utopian robosociety", which imagines a post-capitalist world using robots to provide welfare equally to everyone. In this perspective, "robots' rights" would deem that eventually people should treat robots as equals to human beings. That said, previous research has also suggested people have anxiety about robots replacing humans in large numbers in the labour force (Gnambs, 2019), as well as concerns about technology addiction, the effects of robots on human relations, the risk of a dystopian future, the use of killer robots, the lack of overall control in robotics development, and both general and specific ethical questions (Cave et al., 2019; Horowitz, 2016; Operto, 2019; Torresen, 2018). All of these concerns were identified on display in the studied comments.

The findings thus confirm previously reported results. Adding to the current literature on smart robots is the finding that the majority of public discussion focuses on the impacts and implications of robots on society. There seems to be little interest in contemplating how humans should treat these robots, in the study, especially so-called "smart robots". This supports the argument by Anderson et al. (2010), which called for more discussion on what robots' rights might look like in the notion of "roboethics". Also, a general lack of discussion on robots that adequately takes into consideration various current environmental perspectives and challenges, marks an interesting gap to be filled in the literature.

The findings also provide implications to technical and business practitioners in smart robotics. The lack of transparency in robotics design was mentioned as a specific problem under the theme of "liabilities and ethics". This suggests that robotics manufacturers need to increase the transparency of their design processes, especially in regard to robots' learning and decision-making algorithms, which specifically relate to what and how the robots "decide" to respond and act in specific environments and situations. In other words, this refers to what the robot is programmed to do by the designer, in contrast with what can be unexpected and potentially inappropriate outcomes of a robot's learning and mimicking processes. Transparency from robotics entrepreneurs and manufacturers would not only help users to better understand a robot's potentially awry behaviour, but also assist legal actors with whatever liability issues may arise involving accidents or inappropriate actions by smart robots.

Further, the findings support advice put forward in previous literature, especially by Borenstein and Pearson (2013), and Vandemeulebroucke et al. (2018), who argue

The Ethical Dimensions of Public Opinion on Smart Robots

Mika Westerlund

that representatives from the target market of smart robots, such as elderly people and health and wellness or medical patients, should be involved in the design process as extensively as possible (a kind of "universal design" for robotics), and should have a voice in roboethics debates as well. A projection from this research is that addressing transparency issues in robotic product development may help contribute to better understanding the possibilities and limitations of the new technologies, thus leading to more familiarity, and increased adoption of smart robots as time goes on.

There are several limitations and avenues for future research in the current study. First, this public opinion measurement at a general level did not take into consideration sociological or political differences in attitudes between any types or groups of people. For example, the issue of "robots replacing humans as labour force" may be overly represented in the data, as readers who left comments were not identified. This group of commenters may, for example, consist mainly of people who do not have any experience with smart robots, so the capacity of their answers would be quite limited. Tuisku et al. (2019) found that people who had experience with robots at work had more positive attitudes about robots than those that did not. In their study, workers having experience with robots more often viewed robots as helpful tools, rather than as potential replacements for their jobs.

Thus, while analyzing publicly available qualitative data, such as comments sections in news articles can be useful, it is not intended to, nor could it ever replace targeted surveys that allow for comparisons based on demographic, sociographic, and other factors. Second, the articles chosen for this investigation may have affected the findings, which was a necessary risk in the filtering process. For example, Gardiner et al. (2016) note that articles in the "technology" section of The Guardian, such as those used in this study, tend to receive more comments from men compared to women, thus reflecting a gender gap in opinions. Further, a news article that takes a strong stance framing robots as a threat to the human labour force is likely to impose more comments with a more negative tone on that specific topic. Although the four articles on smart robots chosen for investigation were deemed largely neutral in tone, it is impossible to rule out the content and focus of the news article itself. Future research should therefore investigate a larger number of news articles and their commentaries, in order to balance potential biases through "scale effects". Third, although it was useful to group the themes hierarchically using an ethical framework as a guideline, future research could also study themes in public discussion using tools better suited for quantifying themes in large data sets, such as topic modelling and hierarchical clustering software. Overall, the study reflected that research on public opinion regarding ethics involving robotics and smart robots is an important area which deserves more attention in the future.

References

Alsegier, R. A. 2016. Roboethics: Sharing our world with humanlike robots. *IEEE Potentials*, 35(1): 24–28. http://dx.doi.org/10.1109/MPOT.2014.2364491

Anderson, M., Ishiguro, H., & Fukushi, T. 2010. "Involving Interface": An Extended Mind Theoretical Approach to Roboethics. *Accountability in Research*, 17(6): 316–329. http://dx.doi.org/10.1080/08989621.2010.524082

Anonymous 2014. Rise of the robots. *The Economist*, March 29, 2014, Vol.410 (8880). [Retrieved from: https://www.economist.com/leaders/2014/03/29/rise-of-the-robots]

Beltramini, E. 2019. Evil and roboethics in management studies. *AI & Society*, 34: 921–929. http://dx.doi.org/10.1007/s00146-017-0772-x

Bertolini, A., & Aiello, G. 2018. Robot companions: A legal and ethical analysis. *The Information Society*, 34(3): 130–140. http://dx.doi.org/10.1080/01972243.2018.1444249

Björling, E. A., Rose, E., Davidson, A., Ren, R., & Wong, D. forthcoming. *International Journal of Social Robotics*. https://doi.org/10.1007/s12369-019-00539-6

Bogue, R. 2014a. Robot ethics and law, Part one: ethics. *Industrial Robot: An International Journal*, 41(4): 335–339. https://doi.org/10.1108/IR-04-2014-0328

Bogue, R. 2014b. Robot ethics and law, Part two: law. *Industrial Robot: An International Journal*, 41(5): 398–402. https://doi.org/10.1108/IR-04-2014-0332

Borenstein, J., & Pearson, Y. 2013. Companion Robots and the Emotional Development of Children. *Law, Innovation and Technology*, 5(2): 172–189. http://dx.doi.org/10.5235/17579961.5.2.172

Bradford, A. 2020. Trifo's Lucy robot vacuum won't run over poop, doubles as a security system. Digital Trends, January 3, 2020. [Retrieved from: https://www.digitaltrends.com/home/trifos-lucy-ai-robot-vacuum-wont-run-over-poop/]

The Ethical Dimensions of Public Opinion on Smart Robots

Mika Westerlund

Čaić, M., Odekerken-Schröder, G., & Mahr, D. 2018. Service robots: value co-creation and co-destruction in elderly care networks. *Journal of Service Management*, 29(2): 178–205. https://doi.org/10.1108/JOSM-07-2017-0179

Calabrese, L., & Jenard, J. 2018. Talking about News. A Comparison of readers' comments on Facebook and news websites. *French Journal for Media Research*, 10/2018. [Retrieved from https://frenchjournalformediaresearch.com:443/lodel-1.0/main/index.php?id=1684]

Cave, S., Coughlan, K., & Dihal, K. 2019. "Scary robots": Examining public responses to AI. *AIES 2019 - Proceedings of the 2019 AAAI/ACM Conference on AI, Ethics, and Society*, 331–337. https://doi.org/10.1145/3306618.3314232

Davis, N. 2013. Smart robots, driverless cars work —but they bring ethical issues too. *The Guardian*, 20 October, 2013. [Retrieved from: https://www.theguardian.com/technology/2013/oct/20/artificial-intelligence-impact-lives]

Dekoulis, G. 2017. Introductory Chapter: Introduction to Roboethics —The Legal, Ethical and Social Impacts of Robotics. In Dekoulis, G. (ed.), *Robotics: Legal, Ethical and Socioeconomic Impacts*. IntechOpen. pp. 3-6. http://dx.doi.org/10.5772/intechopen.71170

Devlin, H. 2016. Do no harm, don't discriminate: official guidance issued on robot ethics. *The Guardian*, 18 September 2016. [Retrieved from: https://www.theguardian.com/technology/2016/sep/18/official-guidance-robot-ethics-british-standards-institute]

Döring, N., & Poeschl, S. 2019. Love and Sex with Robots: A Content Analysis of Media Representations. *International Journal of Social Robotics*, 11(4): 665–677. https://doi.org/10.1007/s12369-019-00517-y

Fedock, B., Paladino, A., Bailey, L., & Moses, B. 2018. Perceptions of robotics emulation of human ethics in educational settings: a content analysis. *Journal of Research in Innovative Teaching & Learning*, 11(2): 126–138. https://doi.org/10.1108/JRIT-02-2018-0004

Gardiner, B., Mansfield, M., Anderson, I., Holder, J., Louter, D., & Ulmanu, M. 2016. The dark side of Guardian comments. *The Guardian*, 12 April 2016. [Retrieved from: https://www.theguardian.com/technology/2016/apr/12/the-dark-side-of-guardian-comments]

Gnambs, T. 2019. Attitudes towards emergent autonomous robots in Austria and Germany. *Elektrotechnik & Informationstechnik*, 136(7): 296–300. https://doi.org/10.1007/s00502-019-00742-3

Guest, G., & McLellan, E. 2003. Distinguishing the Trees from the Forest: Applying Cluster Analysis to Thematic Qualitative Data. *Field Methods*, 15(2): 186–201. https://doi.org/10.1177/1525822X03015002005

Haberman, C. 2016. Smart Robots Make Strides, But There's No Need to Flee Just Yet. *The New York Times*, 6 March 2016. [Retrieved from: https://www.nytimes.com/2016/03/07/us/smart-robots-make-strides-but-theres-no-need-to-flee-just-yet.html]

Henry, D., Dymnicki, A. B., Mohatt,N., Allen, J., & Kelly, J. G. 2015. Clustering Methods with Qualitative Data: A Mixed Methods Approach for Prevention Research with Small Samples. *Prevention Science*, 16(7): 1007–1016. https://doi.org/10.1007/s11121-015-0561-z

Hitti, N. 2020. *Ballie the rolling robot is Samsung's near-future vision of personal care.* [Retrieved from: https://www.dezeen.com/2020/01/08/samsung-ballie-robot-ces-2020/]

Horowitz, M. C. 2016. Public opinion and the politics of the killer robots debate. *Research & Politics*, 3(1): 1–8. https://doi.org/10.1177/2053168015627183

Iphofen, R., & Kritikos, M. 2019. Regulating artificial intelligence and robotics: ethics by design in a digital society. *Contemporary Social Science*, https://doi.org/10.1080/21582041.2018.1563803

Javaheri, A., Moghadamnejad, N., Keshavarz, H., Javaheri, E., Dobbins, C., Momeni, E., & Rawassizadeh, R. 2019. *Public vs Media Opinion on Robots*. https://arxiv.org/abs/1905.01615

Kravets, D. 2010. Jan. 25, 1979: Robot Kills Human. *Wired*, January 25, 2010. [Retrieved from: https://www.wired.com/2010/01/0125robot-kills-worker/]

Lichocki, P., Kahn Jr., P.H., & Billard, A. 2011. The Ethical Landscape of Robotics. *IEEE Robotics and Automation Magazine*, 18(1): 39–50. https://doi.org/10.1109/MRA.2011.940275

Lin, P., Abney, K., & Bekey, G. 2011. Robot ethics: Mapping the issues for a mechanized world. Artificial Intelligence, 175(5/6): 942–949. https://doi.org/10.1016/j.artint.2010.11.026

McLuhan, Marshall (1964). *Understanding Media: the Extensions of Man*. Penguin.

Melson, G. F., Kahn, Jr. P.H., Beck, A., & Friedman, B. 2009. Robotic Pets in Human Lives: Implications for the Human–Animal Bond and for Human Relationships with Personified Technologies. *Journal of Social Issues*, 65(3): 545–567. https://doi.org/10.1111/j.1540-4560.2009.01613.x

Müller, V. C., & Bostrom, N. 2016. Future progress in artificial intelligence: a survey of expert opinion. In V. C. Müller (Ed.). *Fundamental Issues of Artificial Intelligence*. Berlin: Synthese Library, Springer: 553–571.

Operto, S. 2019. Evaluating public opinion towards robots: a mixed-method approach. Paladyn, *Journal of Behavioural Robotics*, 10(1): 286–297.

The Ethical Dimensions of Public Opinion on Smart Robots

Mika Westerlund

https://doi.org/10.1515/pjbr-2019-0023

Steinert, S. 2014. The Five Robots– A Taxonomy for Roboethics. *International Journal of Social Robotics*, 6: 249–260. https://doi.org/10.1007/s12369-013-0221-z

Stokes, P., & Urquhart, C. 2013. Qualitative interpretative categorisation for efficient data analysis in a mixed methods information behaviour study. *Information Research*, 18(1), 555. [Available at: http://InformationR.net/ir/18-1/paper555.html]

Torresen, J. 2018. A Review of Future and Ethical Perspectives of Robotics and AI. *Frontiers in Robotics and AI*, 4:75. https://doi.org/10.3389/frobt.2017.00075

Tsafestas, S. G. 2018. Roboethics: Fundamental Concepts and Future Prospects. *Information*, 9(6), 148. https://doi.org/10.3390/info9060148

Tuisku, O., Pekkarinen, S., Hennala, L., & Melkas, H. 2019. "Robots do not replace a nurse with a beating heart" —The publicity around a robotic innovation in elderly care. *Information Technology & People*, 32(1): 47–67. https://doi.org/10.1108/ITP-06-2018-0277

Vandemeulebroucke, T., Dierck de Casterlé, B., & Gastmans, C. 2018. The use of care robots in aged care: A systematic review of argument-based ethics literature. *Archives of Gerontology and Geriatrics*, 74: 15–25. https://doi.org/10.1016/j.archger.2017.08.014

Verdinelli, S., & Scagnoli, N. I. 2013. Data Display in Qualitative Research. *International Journal of Qualitative Methods*, 12(1): 359–381. https://doi.org/10.1177/160940691301200117

Veruggio, G., & Operto, F. 2006. Roboethics: a Bottom-up Interdisciplinary Discourse in the Field of Applied Ethics in Robotics. *International Review of Information Ethics*, 6: 2–8.

Veruggio, G., & Operto, F. 2008. Roboethics: Social and Ethical Implications of Robotics. In Siciliano, B. & Khatib, O. (Eds.). *Springer Handbook of Robotics*. Springer: Berlin. pp. 1499–1524.

Veruggio, G., Solis, J., & Van der Loos, M. 2011. Roboethics: Ethics Applied to Robotics. *IEEE Robotics & Automation Magazine*, 18(1): 21–22. https://doi.org/10.1109/MRA.2010.940149

Westerlund, M. 2020. An Ethical Framework for Smart Robots. *Technology Innovation Management Review*, 10(1): 35–44. http://doi.org/10.22215/timreview/1312

Yu, C.-E. 2020. Humanlike robots as employees in the hotel industry: Thematic content analysis of online reviews. *Journal of Hospitality Marketing & Management*, 29(1): 22–38. https://doi.org/10.1080/19368623.2019.1592733

About the Author

Mika Westerlund, DSc (Econ), is an Associate Professor at Carleton University in Ottawa, Canada. He previously held positions as a Postdoctoral Scholar in the Haas School of Business at the University of California Berkeley and in the School of Economics at Aalto University in Helsinki, Finland. Mika earned his doctoral degree in Marketing from the Helsinki School of Economics in Finland. His research interests include open and user innovation, the Internet of Things, business strategy, and management models in high-tech and service-intensive industries.

Citation: Westerlund, M. 2020. The Ethical Dimensions of Public Opinion on Smart Robots. *Technology Innovation Management Review*, 10(2): 25-36. http://doi.org/10.22215/timreview/1326

Keywords: Smart robot, Ethics, Public opinion, Roboethics, Content analysis

Integrated Innovation and Sustainability Analysis for New Technologies: An approach for collaborative R&D projects

Johannes Gasde, Philipp Preiss, Claus Lang-Koetz

> *"The greatest threat to our planet is the belief that someone else will save it."*
>
> Robert Swan,
> the first person to walk to both Poles

In order to effectively shape the impact of an innovation on sustainability, the early phases of the innovation process are crucial. This is especially true for complex collaborative R&D projects with multiple partners. We have found that there is an increasing need for simple methods that enable partners in such R&D projects to guide them towards sustainability-oriented innovations (SOI). In response, we have developed a methodology called Integrated Innovation and Sustainability Analysis (IISA). It is based on the early involvement of stakeholders, along with a sustainability assessment of the planned innovation to provide feedback loops into technology development. The overall goal of the method is to improve the potential impact on sustainability in the three dimensions: economic, environmental, and social. The IISA method and its application in two collaborative R&D projects with several research and industry partners that serve as practical examples, is presented and discussed in this paper.

Introduction

One of the most well-known definitions of sustainable development was coined in a United Nations report on our common future: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 1987). The concept of "sustainability" can be concretized by using the so-called "triple bottom line" approach, which differentiates it into environmental, social, and economic dimensions (Elkington, 1997, 2006, 2013), for implementation into daily business practices (McElroy & van Engelen, 2012).

Innovation that serves not only to generate economic returns, but also adds social and environmental value can be defined as sustainability-oriented innovation (SOI) (Klewitz & Hansen, 2014). This type of innovation contributes to improved sustainability with respect to production, market, and consumption (Schaltegger & Wagner, 2011).

The social and environmental value of an innovation can be dynamic, rather difficult to quantify, and is often only revealed after a certain time (Adams et al., 2016; Kemp & Pearson, 2007). SOIs can be products, processes, services, or business models that are new to the organization, and characterized by their focus on environmental aspects, specifically material and energy efficiency (Kemp & Pearson, 2007), and/or social aspects. However, the decisive point is a focus on reducing environmental impact over the whole ecological life cycle (Kemp & Pearson, 2007; Schiederig et al., 2012). Drivers of SOIs can be expected improvements in performance, public perception, and legal compliance. Barriers include lack of information, general doubts, legal compliance, and perceived lack of profitability (Cagno & Trianni, 2014; Clausen et al., 2011).

The early phases of innovation are crucial for shaping SOIs. They are characterized by a high degree of possible influences on production, product and service properties, and corresponding environmental impacts (see Figure 1). However, an exact determination of these

impacts is difficult due to the still unknown material composition and physical processes required for production and logistics (Lang-Koetz et al., 2008). Hence, appropriate Life Cycle Thinking methods such as Life Cycle Assessment (ISO 14040, 2006) are difficult to apply in practice, and thus require simplification.

To achieve significant transformations towards sustainability, there is a need for new frameworks, tools, and methods for products, services, and strategic development (Gaziulusoy & Brezet, 2015). Changes should be implemented with respect to an organization's philosophy, values, and "corporate culture" (Adams et al., 2016). Methods for early phases in the innovation phase have been proposed by various authors (Hallstedt et al., 2013; Hansen et al., 2009; Lang-Koetz et al., 2008; Schimpf & Binzer, 2012; Stock et al., 2017), most of which are presented as concepts, and only partially accompanied by demonstrations of practical application. Moreover, they focus on application inside a company. Beyond that, however, an increasing need has been shown for simplified methods that enable partners in R&D collaborations to be guided towards SOIs.

This study addresses a research gap wherein prevalent methods of innovation management and sustainability assessment have so far rarely been considered in an integrated approach. Several authors see the need for better methodological support to integrate sustainability aspects into early phases of an innovation process (Cancino et al., 2018; Charter & Clark, 2007). It is becoming increasingly necessary to have an integrated approach of innovation management and sustainability assessment, since, (i) many sustainability aspects can already be influenced and controlled at an early stage of innovation, and (ii) sound analysis of the sustainable effects of an innovation is essential to help avoid undesirable economic, environmental, and social impacts. Towards a contribution to this topic, the following research question is addressed in this paper: How can the impacts on sustainability of a technology-based innovation at an early stage be analysed in a simple integrated approach?

Stakeholder Involvement in Innovation Management and Sustainability Assessment

Academic engagement in university-industry relations can range from collaborative research, contract research, and consulting, to informal relations for university-industry knowledge transfer (Perkmann et al., 2013). Collaborative research is a common tool for bringing together knowledge from different

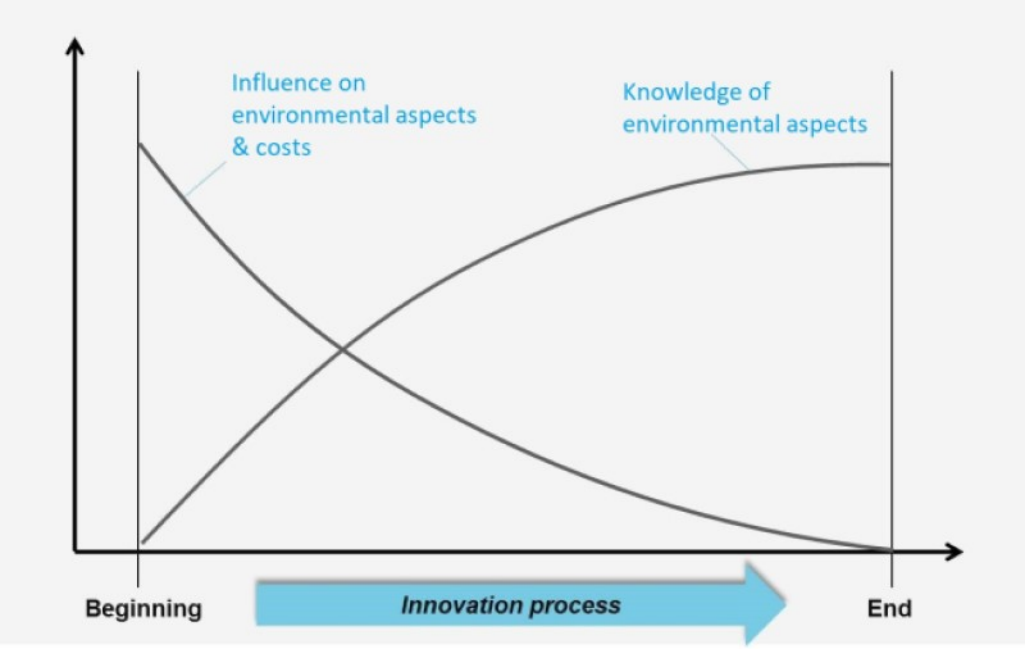

Figure 1. Influence on and knowledge of environmental aspects in an innovation process. (Source: Lang-Koetz et al., 2008, adopted from Züst, 1998)

organisations in academia and industry. It is often used to conduct research and development for complex technologies, and such R&D projects are typical examples of joint/collaborative research (Vahs & Brem, 2015). Technology partnerships are known to be difficult to handle but can have positive effects on innovative performance (Lokshin et al., 2011). Technological capabilities in collaborative R&D projects are developed based on accumulating shared experience and knowledge, mutual dependence, and establishing trustful relationships over time (Bäck & Kohtamäki, 2015, 2016). These findings also appear valid for publicly funded collaborative R&D projects that can help companies to "gain in terms of innovation", if they have the right in-house capabilities and if the project is set up in the right way (Spanos et al., 2015). This paper focuses on such kinds of R&D endeavours, and especially how they can be supported through an integrated stakeholders' perspective on innovation and sustainability involving a new technology or service.

Innovation management can also support the organization of R&D projects with suitable methods. Examples are idea workshops/competitions, customer observation, feasibility studies, creativity techniques, and user integration (Spath et al., 2012; Tidd & Bessant, 2017; Trott, 2012; Vahs & Brem, 2015). The importance of involving stakeholder in innovation management has been recognized widely as crucial (Cancino et al., 2018; Charter & Clark, 2007). All stakeholders perceive various different fostering and hindering factors, which determine their attitude towards the implementation of an innovation. In the context of this study, the term "stakeholder" is considered in a broad sense. Not only direct actors within the collaborative R&D projects are considered as stakeholders, but also all organizations, groups, and individuals in general that affect or are affected by achieving the project's objectives. This understanding of "stakeholder" is based on Freeman (2010).

In the field now known as "sustainability science", there are already some well-established and recognized methods to assess possible effects of products and services, for example, Life Cycle Thinking, Life Cycle Assessment (LCA), and sustainability assessment (Clift & Druckman, 2016; Cucurachi et al., 2018; Guinée et al., 2018; ISO 14040, 2006; ISO 14044, 2018; Jolliet et al., 2016; JRC-IES, 2010; UNEP-SETAC, 2011). However, sustainability assessment for a technology in the early stages of its development is still difficult due to often limited information on the complete physical composition and potential of the future product and its expected life cycle.

Overall, successful stakeholder integration and sustainability assessment are crucial for large-scale SOI projects. We believe this makes a "how to" study on the topic relevant to the field. The approach presented in this paper brings in a new perspective to the existing debate involving sustainable innovation, which brings with it the potential to influence current management methods.

Research Methodology

We address the research question as follows. First, we identified the demand for a methodology to assess the sustainability impact of a technology in its early phases of development from the following sources: a literature review, conversations with practitioners from the German industry, as well as several calls for proposals for collaborative R&D projects from the German Federal Ministry of Education and Research (BMBF). Conceptual research was then conducted to determine how sustainability impact assessment can be conducted in R&D projects in a way that better enables the integration of stakeholders. This resulted in coming up with the methodology "Integrated Innovation and Sustainability Analysis (IISA)", which was then refined while planning two collaborative R&D projects with partners from industry and academia. Both projects received funding from the German government (BMBF). The IISA methodology was adapted to the specific context and then applied in both projects over the course of approximately 3 years. This served to validate the application. Our research was conducted in an action-based setting, which means that the authors were also active members of both project consortia.

Result: A Method – Integrated Innovation and Sustainability Analysis (IISA)

We developed the IISA methodology based on stakeholder involvement in three successive stages, and a sustainability assessment for planned innovation at an early stage. Our principal approach of IISA for SOIs is illustrated in a scheme in Figure 2.

IISA first shows that stakeholder involvement must be systematic based on the characteristics of a planned innovation. The overall goal is to ensure sustainability in all three dimensions (economic, environmental, and social) through stakeholder involvement. Thus, the state

Integrated Innovation and Sustainability Analysis for New Technologies: An approach for collaborative R&D projects

Johannes Gasde, Philipp Preiss, Claus Lang-Koetz

of technological development is regularly discussed with relevant stakeholders. Continuous feedback loops are created in order to enable recommendations for further R&D efforts on the technology. In this context, three elements are used (see Figure 3) and described in the following sections: stakeholder analysis, stakeholder dialogue, and stakeholder integration.

Stakeholder Analysis

The first step is to conduct a stakeholder analysis to obtain a holistic view of the value chain from a life cycle perspective. For this purpose, the following methods are used:

- Stakeholder mapping,
- Interest/influence portfolio,
- Illustration in the life cycle perspective.

Stakeholder mapping can be used to analyze stakeholder groups and their relationships (Bourne & Walker, 2005; Künkel et al., 2016). It is used here to gain a better understanding of the system itself, the flow of information, and the dynamics of the system. The relevance of the stakeholder groups is assessed by classifying them in an influence/interest portfolio (Künkel et al., 2016). This leads to an indication of which stakeholder groups are suitable for further dialogue or integration. Finally, the expected life cycle (from cradle to grave) is analyzed and then illustrated. Depending on available resources different levels of effort are possible in the stakeholder analysis: from one's own experience or internet research (low effort), in-company/project group discussion, or selected interviews (medium effort), to multiple interviews and surveys (high effort).

Stakeholder Dialogue

The next step is stakeholder dialogue. This enables the project team to exchange information with relevant actors, generate acceptance for the innovation, and to attract potential partners for stakeholder integration (Künkel et al., 2016; Lenssen et al., 2006). Furthermore, such a dialogue is crucial to identify expectations, barriers, and drivers for a new technology.

Another important aspect is mediation between competitors or industries. To limit the effort, we suggest prioritizing dialogue activities according to the above-mentioned influence/interest portfolio (Künkel et al., 2016):

Figure 2. Integrated Innovation and Sustainability Analysis (IISA) for sustainability-oriented innovation.

Integrated Innovation and Sustainability Analysis for New Technologies: An approach for collaborative R&D projects

Johannes Gasde, Philipp Preiss, Claus Lang-Koetz

- Powerful stakeholders with high interest: engage in a dialogue,
- Powerful stakeholders with little or no interest: create awareness for technology and potential benefits,
- All other identified stakeholders: stay in loose contact.

The following methods are proposed for dialogue (used in combination, where appropriate): (i) preparation and transfer of information on the new technology/service and its potential benefits, (ii) interview, (iii) survey, (iv) public event, (v) workshop. Further information on the characteristics of these methods is provided in Table 1. A workshop, for example, can be used to present the current developmental status to several stakeholders, and could also generate high-quality feedback loops for further R&D.

For the purpose of evaluating the workshop method, four criteria for a successful workshop were defined in advance: (i) fruitful discussion of actual project status with relevant stakeholders, (ii) reflection of different stakeholder perspectives, (iii) feedback loops into innovation process, (iv) dissemination of the innovation among relevant stakeholders.

Stakeholder Integration

In the third step, stakeholders become integrated with regard to market, environment, and social perspectives. The integration can range from smaller to larger-scale activities. For example, stakeholders can provide data, help to disseminate an innovation, or provide continuous feedback loops for R&D.

As a result, a so-called "innovation community" can be established (Fichter & Beucker, 2012). It involves committed representatives of relevant stakeholders to set up an informal network of initiators and key personnel. Within an innovation community synergies are created by individuals bringing together decision-making power, expert knowledge, innovation management skills, and/or access to other productive networks. This can help to work more efficiently on the implementation of the innovation.

Sustainability Assessment

The widely accepted report of the Life Cycle Initiative (UNEP-SETAC, 2011) states: "To get the 'whole picture', it is vital to extend current life cycle thinking to encompass all three pillars of sustainability:

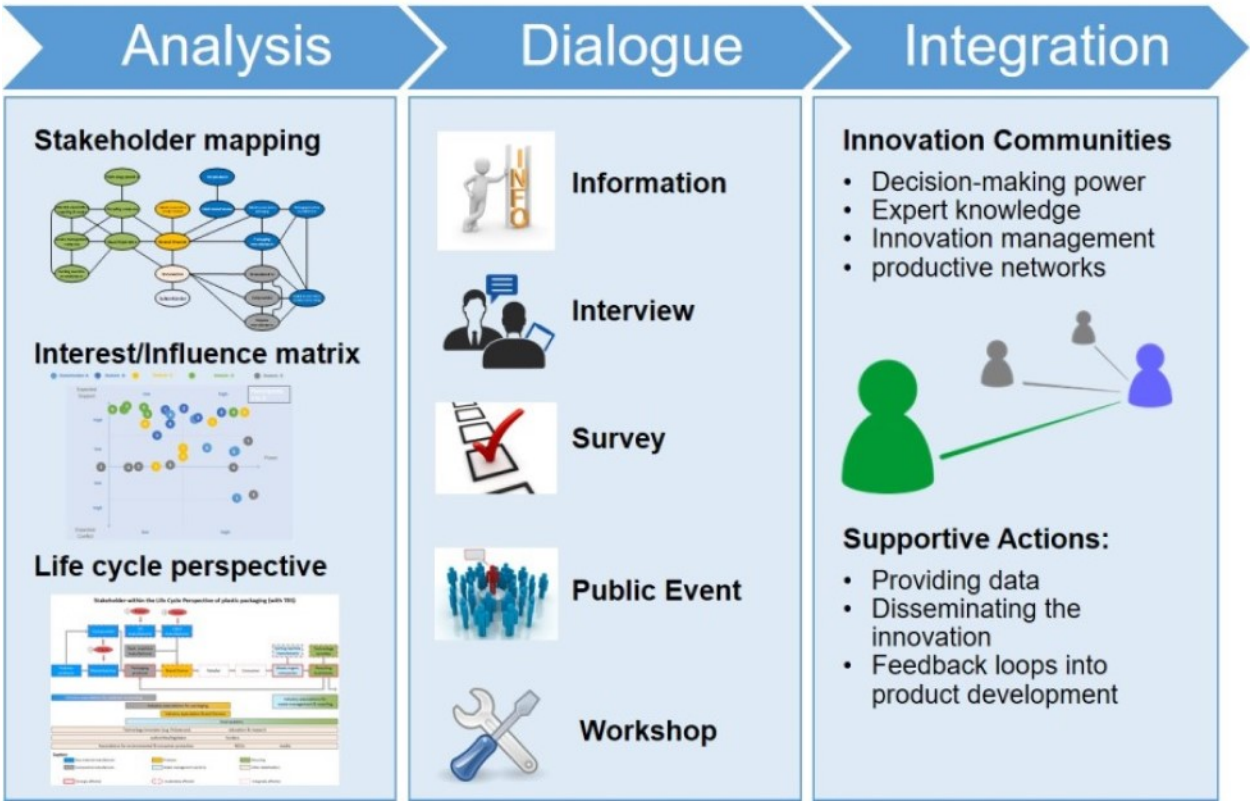

Figure 3. Methodological approach for stakeholder involvement.

Integrated Innovation and Sustainability Analysis for New Technologies: An approach for collaborative R&D projects

Johannes Gasde, Philipp Preiss, Claus Lang-Koetz

(i) environmental, (ii) economic and (iii) social. This means carrying out an assessment based on environmental, economic and social issues — by conducting an overarching life cycle sustainability assessment (LCSA)". Such an assessment consists of an Environmental Life Cycle Assessment (LCA), an economic assessment, and regarding social aspects, which we describe in the following paragraphs.

Environmental Life Cycle Assessment (LCA)
An Environmental Life Cycle Assessment (LCA) relies on a so-called Life Cycle Inventory (LCI). The LCI is based on data on energy and material flows, over the life cycle of a product or service "from cradle to grave". For example, materials used for building various devices must be determined, transport activities considered, electricity procured for operating devices, as well as the final deposition at the end of the lifetime of devices have to be taken into account.

Since much information cannot be exactly measured, a so-called streamlined LCA (using experts estimates for assumptions), with scenarios and hotspot analysis is needed to estimate the potential environmental impact of an innovation at its early stage. Corresponding pollutant emissions are derived using an LCI database such as ecoinvent (Wernet et al., 2016). Such databases contain process data corresponding to present conditions. However, investigating the possible impact of technologies still in development means that an LCA has to consider that the technology will be applied in the near future (about 5 years from now). Hence, any LCI data collected should be adjusted to future conditions. This means that a so-called exploratory LCA method (also called prospective or ex-ante LCA) may also be used (Cucurachi et al., 2018). This approach takes future developments into account, for example, by using a different electricity mix than now.

Economic Assessment
The economic sustainability assessment is done based on the "Total Cost of Ownership" (TCO) approach (Ellram & Siferd, 1998). Analogous to the LCA of environmental issues, it takes investment and operation costs occurring during all life cycle stages into account. The application of TCO approach can help to reveal

Table 1. Appropriate methods for stakeholder dialogue. Own illustration based on Künkel et al. (2016).

Method	*Characteristics*	*Effect*	*Output*	*Effort*
Preparation and transfer of information	Presentation, webinar, mail/newsletter; unidirectional	External	awareness	low
Interview	Open or (semi-) structured, via phone or in person; bidirectional; creativity-promoting	internal; external	feedback for R&D; qualitative data	medium
Survey	standardized questionnaire; unidirectional; low explicability;	Internal	feedback for R&D; quantitative data	medium - high
Public event	Road show or demonstration; unidirectional	external; between participants	awareness; acceptance	medium
Workshop	Presentation, demonstration + SH working groups; multidirectional; creativity-promoting	internal; external; between participants	awareness; feedback for R&D; quantitative & qualitative data	high

costs of the implementation of a technology such as expenditure on additional vocational training or the costs for disposal of waste. Moreover, advantages of an alterative technology with higher initial investment costs but lower energy demand during operation phase can be explained.

Regarding Social Aspects
The methodology for conducting social life cycle assessment (S-LCA) (Benoît & Mazijn, 2009; Goedkoop et al., 2018) is still under development. General standardized indicators that reflect social impacts along a product's life cycle, together with its supply chains, are still not available. Many of the available indicators seem to be rather relevant for developing countries. However, due to global supply chains these can also be relevant for products or services used in more developed countries. The S-CLA methodology is based on stakeholder categories and corresponding indicators (UNEP/SETAC, 2009). The stakeholder categories are worker, consumer, local community, society, and further "value chain actors". For example, for the stakeholder category "worker" there are subcategories such as fair salary, working hours, or child labor listed. Due to its potential complexity and uncertainty, an actual S-LCA is not included in our IISA methodology, at least not yet. However, within stakeholder dialogue for our use case (interviews and workshop), several social aspects were revealed and discussed. Examples of these are characteristics such as personnel requirements (qualifications for operating devices), potential threats, and occupational health.

Integration due to feedback to technical development
Insights and implications from stakeholder involvement and sustainability assessment should be used as feedback for people conducting the project's technical R&D. For example, if a certain process leads to a high energy consumption resulting in CO_2 emissions, efforts of R&D can be focused to try to change the process' design.

The integration of relevant stakeholders and the technology sustainability assessment, thus expands the options and possibilities for feedback loops and overall project optimization at an early stage. The interactions and interrelations between stakeholders and life cycle data (as the basis for sustainability assessment) are illustrated in Figure 4.

Method Validation

The proposed IISA method was applied and evaluated in two practical examples: the collaborative R&D projects DiWaL and MaReK. Both projects have been conducted by consortia of research institutes and companies in Germany. They can be regarded as typical R&D collaborations, characterized by common objectives

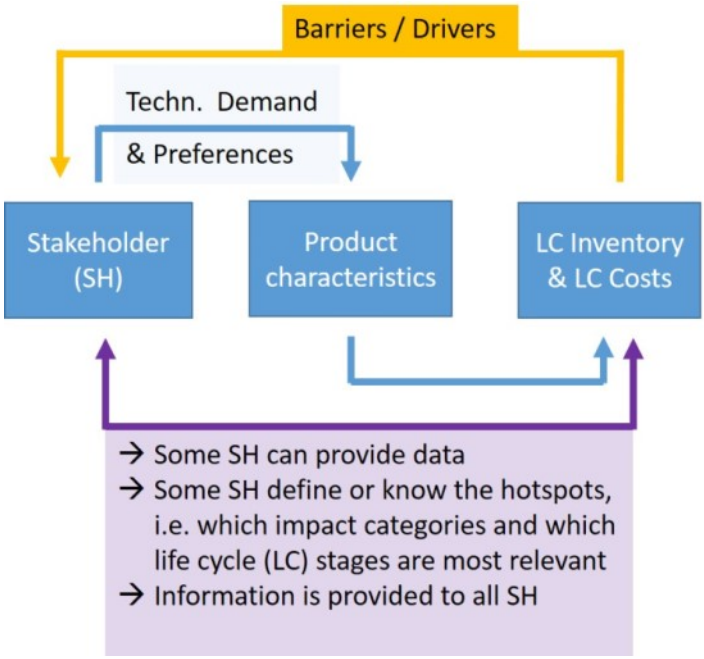

Figure 4. Feedback loops between stakeholders (SH) and life cycle data in sustainability assessment.

such as closing a specific innovation gap, and establishing an explicit division of tasks and responsibilities. The authors of this study, participants in both projects, believe that these projects can have far-reaching effects on several parts of the value chain in their field.

One project focuses on a new process for plastics recycling (MaReK), the other one on a new process for industrial paint shops (DiWaL). See Table 2 for more information.

MaReK – new technology for plastics recycling of the future

In MaReK, the planned innovation is "Tracer-Based Sorting (TBS)". This is a process by which plastic packaging or their labels are marked with small amounts of certain fluorescing substances ("tracers"). The packaging can then be separated, for example, by type or company origin, during the sorting and recycling of mixed plastic waste. Within this project, it is vital to include the entire value-chain of the packaging life cycle. This means packaging design (design for recycling), process development for marker application and packaging sorting, and finally, the recovery of marker substances and recycling materials.

TBS has the potential to become a radical innovation for sorting and recycling packaging, within a targeted circular economy. The innovation can help to generate specification-compliant recyclates with high purity. These can be used to manufacture similar packaging.

Table 2. The two collaborative R&D projects where IISA method was applied (both funded by the German Federal Ministry of Education and Research [BMBF]).

	MaReK	***DiWaL***
Description	**Ma**rker based sorting and **Re**cycling system for plastic pac**k**aging	**Di**sinfection of **Wa**ter and **L**acquer (dip paint), by Pulsed Electric Field Treatment in car body painting plants
Industry & research project partners	Polysecure GmbH; Werner & Mertz GmbH; Der Grüne Punkt – Duales System Deutschland GmbH. KIT - Institute of Microstructure Technology (IMT); INEC - Pforzheim University	BMW Group; Eisenmann Anlagenbau GmbH & Co. KG; Emil Frei GmbH & Co. KG; PPG Deutschland Business Support GmbH; KIT - Institute for Pulsed Power and Microwave Technology (IHM) & Institute of Functional Interfaces (IFG); INEC - Pforzheim University
Budget	2 Mio. € (funded by BMBF)	3.1 Mio. € (funded by BMBF)
Duration	2017-2020	2016-2020
Grant No.	033R195A	02WAV1405C
Website	www.hs-pforzheim.de/marek	www.hs-pforzheim.de/diwal

While expecting to reduce some of the environmental impacts of plastic packaging, the technological implementation remains a complex task. This challenge potentially affects a multitude of stakeholders, and thus if it can achieve a "network effect", may help lead to major changes in the value chain of plastics packaging. Table 3 provides concise information about the results of applying the IISA method in the R&D project MaReK.

DiWaL – renewable electricity instead of chemical biocides for the efficient reduction of micro organisms
In the DiWaL-project, a new Pulsed Electric Field (PEF) technology is the main research focus. It aims to reduce the microbial contamination of paint and other water based processing fluids. It is applied in car body painting plants where there is a high production volume, and a lot of water is consumed. Process fluids in such plants (especially liquid paint) contain microorganisms (MOs) and biofilms. This causes problems regarding the quality of a car's paint finish. Nowadays chemical biocides are applied to disinfect the processing fluids. With a PEF treatment, the MOs are killed with high voltage - a promising alternative that does not rely on biocides, and thus has the potential to be more environmentally friendly. Table 4 provides concise information about the results of applying the IISA method in the R&D project DiWaL.

Table 5 shows how our two practical examples meet the four criteria describing a successful workshop mentioned above. In addition, we provide insights into the strengths and drawbacks of using workshops as a tool for stakeholder dialogue in collaborative R&D projects.

Discussion & Conclusion

We started with a basic question for our research: How can the impacts on sustainability of a technology-based innovation at an early stage be analysed in a simple integrated approach? This question was addressed in the research presented by developing the methodology "Integrated Innovation and Sustainability Analysis". It is based on stakeholder involvement and sustainability

Table 3. IISA validation in the R&D project MaReK.

Method	*Results obtained*	*Recommendations for development*
Stakeholder analysis	- Identification of relevant SHs: brand owners, waste management & recycling companies, packaging producers, politics & regulators. - Communication plan for SH dialogue.	- Address the specific needs of most relevant SHs in further R&D. - Consider circular nature of value-added system in R&D.
Stakeholder Dialogue	- 3 main barriers & drivers identified in interviews with SHs, validated and assessed in SH workshop. - 4 application fields derived in SH workshop.	- Develop for customer-oriented application scenarios. - Innovate existing business models to establish a technology innovation.
Stakeholder Integration	- Enhanced network in the value-added system of plastic packaging.	- Integrate potential partners for further pilot tests/projects.
Sustainability Assessment	- Development of parameterized energy and material flow model. - fluorescing substances do not have significant environmental impacts - Reduction of energy extensive primary production of polymers	- Main benefit lies in reduction of sorting steps and increased use of recyclates in packaging manufacturing.

assessments of planned innovation at early stages. The IISA was applied within two publicly funded R&D-projects in Germany.

As expected, many uncertainties prevailed at the beginning of both projects, for example regarding functional requirements of technological parameters, applicability in the industry, and potential demand from the market. Overall sustainability impact was shown only as a rough estimate, given a lack of information and quantitative data. Nevertheless, we believe that both technologies have the potential to affect a large number of stakeholders, either directly or indirectly. Several stakeholders served as experts for our study, as they were able to estimate technical data, or determine lower and upper limits for crucial assumptions such as energy demand. They also gave valuable input on technical requirements, illustrated new applications of the technologies, and gave hints on how to address possible skepticism towards the proposed solutions in the market. The main barriers for innovation that we found in both projects were uncertainties regarding applicability and specific technical performance parameters.

Table 4. IISA validation in the R&D project DiWaL.

Method	*Results obtained*	*Recommendations for development*
Stakeholder analysis	- Identification of relevant SHs: plant manufacturers, plant operators, PEF and alternative technology developers, manufacturers of paints and chemicals, technical experts and authorities from various subject areas.	- Address specifically the needs of most relevant SHs in further R&D.
Stakeholder Dialogue	- Main barriers include uncertainty about the level of electricity consumption, electricity costs, investment and transaction costs. - Moreover, there is no immediate need for change as conventional process currently provides high quality products and there is no experience of integrating the PEF into existing or new installations. - New & additional requirements have been identified.	- Initiate further references projects / applications. - Explore the potential drawbacks of incumbent technologies and their robustness regarding future regulations. - Include additional requirements in design of the device.
Stakeholder Integration	- Enhanced network. - Important feedback for improvements and actual customer needs.	- Integrate potential partners for further pilot tests/projects. - Search for further applications of PEF treatment.
Sustainability Assessment	- Development of energy and material flow model based on lab scale and demonstration plant. - Understanding of influencing factors for potential environmental impacts. - PEF can reduce water demand and will reduce use of biocides; however, it will increase electricity demand.	- Main benefit lies in optimisation of electricity demand in operation phase. - If future electricity mix includes high shares of renewable and clean energy, the operation on PEF will show smaller environmental impacts.

Integrated Innovation and Sustainability Analysis for New Technologies: An approach for collaborative R&D projects

Johannes Gasde, Philipp Preiss, Claus Lang-Koetz

Assessing the potential sustainability impact of both technologies with the LCA methodology led to valuable results involving potential environmental impact. Although not shown here, concrete recommendations for R&D could be derived from the research to improve environmental impact. We also identified necessary changes in the legal framework, as well as brought into discussion government agencies, since there currently appears to be a high degree of willingness to change the current regulations. Social issues were only addressed to a minor extent.

Scientific Contribution

The scientific contribution of this work lies primarily in the development of the IISA as a simple methodological approach that can assess impacts on sustainability of a technology-based innovations at early stages. It does this in a way that aims to help both identify and integrate stakeholder perspectives. This can serve as a basic method for implementing technology-based SOIs, by integrating an innovation and sustainability perspective. The IISA can be applied for collaborative R&D projects as shown, as well as also other kinds of innovation projects.

Practical Contribution

Applying the IISA method helped to generate valuable feedback about the market environment and user requirements, as well as expected sustainability issues in the early innovation phase. By addressing this in terms of further technological development in two innovation projects, the chances for successfully implementing a SOI increased in both cases. Thus, we believe we have shown that engaging (with) stakeholders successfully and assessing their unique or particular requirements, as well as sustainability factors of (technological) innovations at early stages, are both important for research, and highly relevant for practice. Therefore, we

Table 5. Evaluation of workshops as methodological approach for stakeholder dialogue.

	MaReK	*DiWaL*
Where goals achieved? (++: entirely; --: not at all)	discussion: ++ SH perspectives: + feedback loops: +/- dissemination: +	discussion: ++ SH perspectives: + feedback loops: + dissemination: +/-
What went well?	- Participants from all relevant SH groups. - Fruitful discussion with relevant actors of the value-added system. - Qualitative input for further R&D.	- Participants from all relevant SH groups. - Open discussion with relevant actors; further involvement is welcome.
What did not work out?	- Lack of quantitative data.	- Relatively small number of participants. - Plant operators are either not aware of the potential dependence on alternative solutions or do not see the need or the advantage of collaborating in a R&D project.
Lessons learned (overall)	- There are many other issues in addition to the environmental sustainability which are decisive for certain stakeholders. - Although in the brainstorming on potential barriers and drivers the number of items was quite large, the discussion that followed focused on relatively few main topics. - A very important barrier was and still is the uncertainty of data. - Some stakeholders need "stimulation" for active participation.	

Integrated Innovation and Sustainability Analysis for New Technologies: An approach for collaborative R&D projects

Johannes Gasde, Philipp Preiss, Claus Lang-Koetz

suggest the research calls for further investigations into how the IISA can be applied for other R&D projects.

Acknowledgments

This research was funded mainly by the German Ministry of Education and Research (BMBF) in the research projects DiWaL and MaReK (within the framework program "Research for Sustainable Development" (FONA3), grant numbers FKZ 02WAV1405C and FKZ 033R195A). The authors thank BMBF for its financial support, the partners of both projects for the fruitful collaboration and their valuable input, their colleagues Jörg Woidasky, Tobias Viere and Heidi Hottenroth, the reviewers of this paper for their good advice, and Heike Herbst for proofreading.

References

Adams, R., Jeanrenaud, S., Bessant, J., Denyer, D., & Overy, P. 2016. Sustainability-oriented Innovation: A Systematic Review. *International Journal of Management Reviews*, 18: 180-205. https://doi.org/10.1111/ijmr.12068.

Bäck, I., & Kohtamäki, M. 2015. Boundaries of R&D collaboration. *Technovation*, 45-46: 15-28. https://doi.org/10.1016/j.technovation.2015.07.002.

Bäck, I., & Kohtamäki, M. 2016. Joint Learning in Innovative R&D Collaboration. *Industry and Innovation*, 23: 62-86. https://doi.org/10.1080/13662716.2015.1123613.

Benoît, C., & Mazijn, B. 2009. *Guidelines for social life cycle assessment of products*. Paris, France: United Nations Environment Programme.

Bourne, L., & Walker, D.H.T. 2005. Visualising and mapping stakeholder influence. *Management Decision*, 43: 649-660. https://doi.org/10.1108/00251740510597680.

Cagno, E., & Trianni, A. 2014. Evaluating the barriers to specific industrial energy efficiency measures: An exploratory study in small and medium-sized enterprises. *Journal of Cleaner Production*, 82: 70-83. https://doi.org/10.1016/j.jclepro.2014.06.057.

Cancino, C.A., La Paz, A.I., Ramaprasad, A., & Syn, T. 2018. Technological innovation for sustainable growth: An ontological perspective. *Journal of Cleaner Production*, 179: 31-41. https://doi.org/10.1016/j.jclepro.2018.01.059.

Charter, M., & Clark, T. 2007. *Sustainable Innovation: Key conclusions from Sustainable Innovation Conferences 2003-2006 organised by The Centre for Sustainable Design*. Farnham.

Clausen, J., Fichter, K., & Winter, W. 2011. *Theoretische Grundlage für die Erklärung von Diffusionsverläufen von Nachhaltigkeitsinnovationen: Verbundvorhaben im Rahmen der BMBF Bekanntmachung „Innovationspolitische Handlungsfelder für die nachhaltige Entwicklung“ im Rahmen der Innovations- und Technikanalyse*. Grundlagenstudie. Berlin.

Clift, R., & Druckman, A. 2016. *Taking Stock of Industrial Ecology*. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-20571-7.

Cucurachi, S., van der Giesen, C., & Guinée, J. 2018. Ex-ante LCA of Emerging Technologies. *Procedia CIRP*, 69: 463-468. https://doi.org/10.1016/j.procir.2017.11.005.

Elkington, J. 1997. *Cannibals with forks: The triple bottom line of 21st century business*. Oxford: Capstone.

Elkington, J. 2006. *The triple bottom line. In The accountable corporation*. Westport, Conn. [u.a.]: Praeger Publishers: 97-109.

Integrated Innovation and Sustainability Analysis for New Technologies: An approach for collaborative R&D projects

Johannes Gasde, Philipp Preiss, Claus Lang-Koetz

Elkington, J. 2013. Enter the triple bottom line. In *The Triple Bottom Line: Does it All Add Up*: 1-16. https://doi.org/10.4324/9781849773348.

Ellram, L.M., & Siferd, S.P. 1998. Total cost of ownership: A key concept in strategic cost management decisions. *Journal of Business Logistics*, 19: 55-84.

Fichter, K., & Beucker, S. 2012. *Innovation Communities: Kooperation zahlt sich aus!: Teamworking mit Partnern als Aufgabe des Innovationsmanagements*. Ein Leitfaden für die Praxis. Berlin.

Freeman, R.E. 2010. *Strategic Management: A Stakeholder Approach*. Cambridge: Cambridge University Press.

Gaziulusoy, A.I., & Brezet, H. 2015. Design for system innovations and transitions: A conceptual framework integrating insights from sustainablity science and theories of system innovations and transitions. *Journal of Cleaner Production*, 108: 558-568. https://doi.org/10.1016/j.jclepro.2015.06.066.

Goedkoop, M., Indrane, D., & Beer, I. de. 2018. *Handbook for Product Social Impact Assessment*. https://doi.org/10.13140/RG.2.2.33455.79523.

Guinée, J.B., Cucurachi, S., Henriksson, P.J.G., & Heijungs, R. 2018. Digesting the alphabet soup of LCA. *The International Journal of Life Cycle Assessment*, 23: 1507-1511. https://doi.org/10.1007/s11367-018-1478-0.

Hallstedt, S.I., Thompson, A.W., & Lindahl, P. 2013. Key elements for implementing a strategic sustainability perspective in the product innovation process. *Journal of Cleaner Production*, 51: 277-288. https://doi.org/10.1016/j.jclepro.2013.01.043.

Hansen E.G., Grosse-Dunker F., & Reichwald R. (eds.). 2009. *Sustainability Innovation Cube - A framework to evaluate sustainability of product innovations*.

ISO 14040. 2006. *Environmental management -- Life cycle assessment -- Principles and framework*.

ISO 14044. 2018. *Environmental management - Life cycle assessment - Requirements and guidelines* (ISO 14044:2006 + Amd 1:2017): German version EN ISO 14044:2006 + A1:2018.

Jolliet, O., Frischknecht, R., Bare, J., Boulay, A.-M., Bulle, C., Fantke, P., Gheewala, S., Hauschild, M., Itsubo, N., Margni, M., McKone, T.E., y Canals, L.M., Postuma, L., Prado-Lopez, V., Ridoutt, B., Sonnemann, G., Rosenbaum, R.K., Seager, T., Struijs, J., van Zelm, R., Vigon, B., & Weisbrod, A. 2016. *Global Guidance for Life Cycle Impact Assessment Indicators*. Volume 1.

JRC-IES. 2010. *International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed guidance*. First edition March 2010. EUR 24708 EN. Luxembourg.

Kemp, R., & Pearson, P. 2007. *Final Report of the MEI project measuring eco innovation*. Maastricht.

Klewitz, J., & Hansen, E.G. 2014. Sustainability-oriented innovation of SMEs: a systematic review. *Journal of Cleaner Production*, 65: 57-75. https://doi.org/10.1016/j.jclepro.2013.07.017.

Künkel, P., Gerlach, S., & Frieg, V. 2016. *Stakeholder-Dialoge erfolgreich gestalten: Kernkompetenzen für erfolgreiche Konsultations- und Kooperationsprozesse*. Wiesbaden: Springer Gabler. "https://doi.org/10.1007/978-3-658-10569-3.

Lang-Koetz, C., Beucker, S., & Heubach, D. 2008. Estimating Environmental Impact in the Early Stages of the Product Innovation Process. In S. Schaltegger, M. Bennett, R.L. Burritt & C. Jasch (eds.), *Environmental Management Accounting for Cleaner Production*, Dordrecht: Springer Netherlands: 49-64.

Lenssen, G., Ayuso, S., Ángel Rodríguez, M., & Enric Ricart, J. 2006. Using stakeholder dialogue as a source for new ideas: A dynamic capability underlying sustainable innovation. *Corporate Governance: The international journal of business in society*, 6: 475-490. https://doi.org/10.1108/14720700610689586.

Lokshin, B., Hagedoorn, J., & Letterie, W. 2011. The bumpy road of technology partnerships: Understanding causes and consequences of partnership mal-functioning. *Research Policy*, 40: 297-308. https://doi.org/10.1016/j.respol.2010.10.008.

McElroy, M.W., & van Engelen, J.M.L. 2012. *Corporate sustainability management: The art and science of managing non-financial performance*. Hoboken: Taylor and Francis.

Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'Este, P., Fini, R., Geuna, A., Grimaldi, R., Hughes, A., Krabel, S., Kitson, M., Llerena, P., Lissoni, F., Salter, A., & Sobrero, M. 2013. Academic engagement and commercialisation: A review of the literature on university–industry relations. *Research Policy*, 42: 423-442. https://doi.org/10.1016/j.respol.2012.09.007.

Schaltegger, S., & Wagner, M. 2011. Sustainable entrepreneurship and sustainability innovation: categories and interactions. *Business Strategy and the Environment*, 20: 222-237. https://doi.org/10.1002/bse.682.

Schiederig, T., Tietze, F., & Herstatt, C. 2012. Green innovation in technology and innovation management - an exploratory literature review. *R&D Management*, 42: 180-192. https://doi.org/10.1111/j.1467-9310.2011.00672.x.

Schimpf, S., & Binzer, J. 2012. Sustainable R&D: a conceptual approach for the allocation of sustainability methods and measures in the R&D process. *Proceedings of the R&D Management Conference*, Grenoble, France, May 23-25, 2012. Grenoble. http://publica.fraunhofer.de/eprints/urn_nbn_de_0011-n-2039199.pdf.

Integrated Innovation and Sustainability Analysis for New Technologies: An approach for collaborative R&D projects

Johannes Gasde, Philipp Preiss, Claus Lang-Koetz

Spanos, Y.E., Vonortas, N.S., & Voudouris, I. 2015. Antecedents of innovation impacts in publicly funded collaborative R&D projects. *Technovation*, 36-37: 53-64. https://doi.org/10.1016/j.technovation.2014.07.010.

Spath, D., Linder, C., & Seidenstricker, S. 2012. *Technologiemanagement: Grundlage, Konzepte, Methoden*. Stuttgart: Fraunhofer-Verl.

Stock, T., Obenaus, M., Slaymaker, A., & Seliger, G. 2017. A Model for the Development of Sustainable Innovations for the Early Phase of the Innovation Process. *Procedia Manufacturing*, 8: 215-222. https://doi.org/10.1016/j.promfg.2017.02.027.

Tidd, J., & Bessant, J. 2017. *Managing innovation: Integrating technological, market and organizational change*. Chichester: Wiley.

Trott, P. 2012. *Innovation management and new product development*. Harlow, England, New York: Financial Times/Prentice Hall.

UNEP-SETAC. 2011. *Towards a Life Cycle Sustainability Assessment*.

United Nations. 1987. *Our Common Future - Report of the World Commission on Environment and Development (WCED)*.

Vahs, D., & Brem, A. 2015. *Innovationsmanagement: Von der Idee zur erfolgreichen Vermarktung*. Stuttgart: Schäffer-Poeschel Verlag.

Wernet, G., Bauer, C., Steubing, B., Reinhard, J., Moreno-Ruiz, E., & Weidema, B. 2016. The ecoinvent database version 3 (part I): overview and methodology. *The International Journal of Life Cycle Assessment*, 21: 1218-1230. https://doi.org/10.1007/s11367-016-1087-8.

Citation: Gasde, J., Preiss, P., Lang-Koetz, C. 2020. Integrated Innovation and Sustainability Analysis for New Technologies: An approach for collaborative R&D projects. *Technology Innovation Management Review*, 10(2): 37-50. http://doi.org/10.22215/timreview/1328

Keywords: Innovation and sustainability analysis; R&D collaborations; sustainability-oriented innovation; stakeholder dialogue; stakeholder integration.

About the Authors

Johannes Gasde is a Research Associate at the Institute for Industrial Ecology (INEC) - a research institute at Pforzheim University in Germany. As an industrial engineer he holds the degree MSc Life Cycle and Sustainability. He is currently working in the BMBF-funded MaReK project on a technology innovation in plastics sorting and recycling. His research interests are sustainable innovation and technology management as well as sustainability assessment for new technologies. He joined the INEC in 2018.

Philipp Preiss is also a Research Associate at INEC. In 2002, he received a diploma and a MSc. degree in Environmental Engineering at the University of Stuttgart (Germany) and University of Manchester Institute of Science and Technology (UK), respectively. Until 2013 he worked at the Institute of Energy Economics and Rational Energy Use (IER), University of Stuttgart. His research covered mainly the development and application of life cycle impact assessment methodologies and the estimation of external costs with a focus on air pollutants emission due to energy converting technologies. From 2014 till 2016 he worked at the European Institute for Energy Researcher (EIFER). He was involved in the research project ene.field regarding the sustainability assessment of fuel cell micro-combined heat and power. Since 2017 he is working at the INEC.

Dr. Claus Lang-Koetz is a professor for Sustainable Technology and Innovation Management at the Business School of Pforzheim University (since 2014). He is conducting publicly and privately funded research projects at INEC. Claus studied Environmental Engineering and Water Resources Engineering and Management at the University of Stuttgart, the University of Utah and Montana State University in the USA. He then worked in applied research for nine years at the University of Stuttgart (Institute for Human Factors and Technology Management) and the Fraunhofer Institute for Industrial Engineering IAO where he was head of the research group Innovative Technologies. He received his doctoral degree (Dr.-Ing.) in 2006 at the University of Stuttgart. From 2009-2014, he was Head of Innovation Management at an international plant equipment and systems provider based in Böblingen, Germany.

Kondratieff's Economic Waves and Future Scenarios Planning: an approach for organizations

Marcos Ferasso and Eloisio Andrey Bergamaschi

"Those who do not learn history are doomed to repeat it."

George Santayana

This manuscript aims to present connections between scenario building techniques and Kondratieff's long economic waves, as a way of identifying patterns in medium and long-term planning for companies' future scenarios. This essay considers two different conceptual contributions to improve forecasting on organizations taking as a departure point Kondratieff's economic waves and Schwartz's future scenario planning. Analyzing these two theoretical contributions, we concluded that the information obtained through the path of Kondratieff's waves can delineate future scenarios as a way to anticipate challenges, opportunities, and threats for organizations' contingency planning. As a contribution for practitioners, considering these two approaches together enables greater performance for strategic planning of future scenarios that can be applied by organizations across a range of industries.

1. Introduction

Thinking about the future is clearly not a new subject. Ancient Greeks sought inspiration for their doubts about the future in the Oracle of Delphi, one of humanity's early efforts to better understand the future. Nowadays, looking for anticipatory trends and trying to understanding the pathways of technological changes, with a wide range of future possibilities, constitute practical and pressing challenges for managers. This makes them a central theme for organizations and nations who care about the way they navigate forwards.

The need to reduce the uncertainties and risks, the growing economic competitiveness on national and international levels, and the need to anticipate trends, and verify new opportunities have highlighted the importance of visualizing the future and learning from it (Nefiodow & Wilenius, 2017).

According to Coates (2003), knowledge generated by exploring the future has direct implications for the planning the present. Otherwise, activities that regard thinking about the future, will be seen as mere entertainment that brings ineffective results to organizations.

Despite many planning efforts and goodwill, organizations of all kinds are nevertheless subject to decline and may face the threat of financial bankruptcy. The need to study the future becomes relevant for its contribution to the strategic planning of organizations. The main point concerning planning failures is that usually only one person, or a small group of people with leading roles, drive the future success of a project, plan, or even an entire organization. Another reason to explore the future is to help people discover their own assumptions.

A technology assessment must be taken into account when considering the need for investment in technology to achieve a promising outcome. To conduct such an assessment future scenarios and Kondratieff's waves offer two approaches that fulfil the need for decision makers in choosing among technologies for investment. Nefiodow and Nefiodow (2014) stressed the need to consider long-term macroeconomic scenarios in conjunction with innovation and technology challenges, thus evidences the need for further development of this combination approach.

We focus in the paper on long economic waves. The Russian economist Nikolai Kondratieff sought to

empirically demonstrate a pattern of repetition in a series of events throughout history. The coincidences of these events, evidenced empirically, seemed to Kondratieff to demonstrate the behavior of expansion and economic recession. The study of long economic waves allows a projected extrapolation of this behavior for future periods (Kondratieff, 1935; Grinin, et al., 2016).

Analyzing the long economic waves proposed by Kondratieff can be useful for building a process for future scenarios. The waves bring elements that have already been empirically tested, and at least partially validated over the years. However, our analysis also addresses the impact of the changes that new information and communication technologies (ICTs) have brought to the acceleration of knowledge diffusion process on new technologies. This has consequently reduced the waves' periods, and often leads to changes in the economic and technological scenarios.

From these contributions, arises our research question: How can Kondriatieff's long economic waves foster future scenarios planning for organizations' technology assessment?

The aim of this research is to present a connection between scenario-building techniques, and Kondratieff's long economic waves. This is done to identify patterns in medium and long-term future planning scenarios for companies. In the first part of the article, we introduce future studies on a theoretical level, thus emphasizing the construction of scenarios techniques. Further, we give a brief exposition about Kondratieff's work on long economic waves. The relation between these two, a theory and a technique, is presented at the end of this paper, demonstrating how to use the Kondratieff waves view as a way to support the improved construction of future scenarios.

The originality of this manuscript lies in joining a theory and a technique for helping the forecasting of organizations' decision-makers. We combined Kondratieff's waves and future scenarios planning in order to help practitioners identify patterns in economic waves that can be useful for forecasting. Thus, the ideas presented below intend to address companies that already use scenario planning, since some decision-makers may show a bounded recognition of 'cyclical' patterns instead 'wave-shaped lines', or other patterns. We believe that that considering and identifying patterns is a basic task in scenario planning, and also that Kondratieff's theory provides key support for forecasting and scenario planning techniques. This approach presented in this paper can be used or applied in contrast with predictive analytics, forecasting, foresight, and prospecting analyses.

This manuscript builds upon theoretical precepts by advancing ideas (Knorr & Verba, 2019), in a way that mainly links two different considerations from the fields of strategy and economics. The authors selected core theoretical contributions from a range of literature in both fields, in order to establish lines of thought and abstractions.

This manuscript is structured as follows. After introducing the theme and the need for greater exploration, we start reconceptualising the literature on future studies, stressing how to conceive of future building alternatives. We then briefly explore technology assessment, forecasting, foresight, and the construction of future scenarios concepts and approaches. After reviewing the literature on future studies, we present Kondratieff's economic waves, mainly focusing on the patterns he identified, in light of the growing pace of pattern change identified in the so-called fifth and sixth economic waves. The next section builds the edge of future scenarios techniques with Kondratieff's waves. In the last section of paper follows the conclusion, including suggestions for further studies.

2. Studies about the Future

For decades, organizations have been trying to incorporate predictions or visions about the future into their planning processes. Such knowledge allows organizations to make decisions that enable them to exploit advantages for future opportunities, as well as anticipate threats to enable them to be overcome. Prospective analysis is a solid basis for institutional sustainability, that helps to produce a more systematic understanding of organizational environments, including variables of behaviour, which are relevant for defining forward-looking institutional strategies (Castro & Lima, 2001).

The future is something that does not exist and cannot be achieved, since when the future has finally arrived, it will be the present that is reached, not the future (Marinho & Quirino, 1995 as cited in Castro & Lima, 2001). So, studying the future involves images or perceptions about this future, which can make an impact on present actions, for both individual persons and the organizations concerned.

Future studies as a field involves techniques for probing,

Kondratieff's Economic Waves and Future Scenarios Planning: an approach for organizations

Marcos Ferasso and Eloisio Andrey Bergamaschi

experimenting, pushing, and engaging people. As underlined by Coates (2003), "one principal reason for studying the future is to widen intellectual horizons and make people aware of factors outside of their normal expert concerns that may converge on their interests in anywhere from 5 to 50 years, presenting an opportunity or a substantial risk, or demanding change for other reasons". Future studies thus may bring up relevant issues to the organisation's future (Coates, 2003), to help awaken to what they believe, as a way to make it explicit to themselves and to the group in which they work.

Here we raise the idea of 'multiple and uncertain futures' (Figure 1), where a projection from the past is one of several possibilities. This way, interaction between historical tendencies and hypothetical events determines the future (Castro & Lima, 2001).

The term 'technological prospecting' refers to activities that focusing prospectively on technological changes, changes in functional capacity, or on the timing and significance of an innovation. Technological prospecting aims to predict possible future states of technology, or conditions that affect an innovation's contribution to an established goal (Coelho, 2003).

Technological prospecting is related to economic and social prospecting. Economic prospecting is relevant, since decision makers must make the best use of available resources for commercializing or using a technology. Thus, managers must know the costs of technology, human capital, and infrastructure that will be involved, as well as understanding the forces that guide the market.

Although there is no consensus, some prospective approaches can be distinguished, albeit sometimes applied without distinction (MDIC/STI, 2001):

- Technology Assessment: monitoring and identifying signs of change, carried out in a more or less systematic and continuous way;
- Forecasting: considering historical information, mathematical modeling, trends and analysis of future projections and hypothetical situations, normally executed periodically; and
- Foresight: developed mainly through the interactive work of specialists, oriented to anticipate possibilities on innovations, not necessarily based on trend information, but rather on speculative projections of their own knowledge, occurring in a non-systematic way.

The prospecting model aims to identify a desirable future among viable alternatives. This implies characterizing an articulated system of actors (involving interests, alliances, and conflicts) and variables (tendencies and ruptures) that influence the desired future, and to expand situations for this system to become compatible with it. Once the discrepancies between the present situation and the future objective have been considered and identified, strategies adopted in the present should then be established to lead to constructing the desired future (MDIC/STI, 2001).

One attempt to study the future can be found in the field of economics. Economists such as Nikolai Kondratieff tried to determine the cyclic occurrence of events in a way of predicting future economic waves. Although Kondratieff was successful in his attempts, his empirical evidences were proven in a period where technology development was growing in a more predictive scenario.

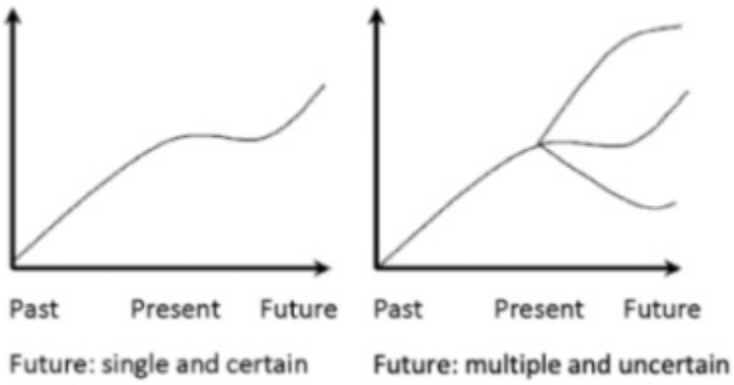

Figure 1. Future building alternatives
Source: adapted from Castro and Lima (2001).

Kondratieff's Economic Waves and Future Scenarios Planning: an approach for organizations *Marcos Ferasso and Eloisio Andrey Bergamaschi*

This is the reason why we need to emphasize technology assessment, forecasting and foresight.

2.1 Technology assessment and forecasting

The term "technology assessment" is known globally in government, politics, and business communities. According to Blair (1994), the concept spread in the late 1960s and began to be applied by the Office of Technology Assessment (OTA) in the United States in 1972. Since technological development has increased at growing rates, anticipating the consequences of its applications became a crucial theme for determining public policies related to current and future problems. Technology assessment aims to study the potential consequences of employing new technologies, in order to provide earlier indications of likely benefits or adverse impacts of a technology's applications.

The National Science Foundation defines technology assessment as a study of policies intended to better understand the consequences for society, regarding the extension of existing technologies or the introduction of new ones, whose effects usually would not be planned or anticipated (Coates, 2004).

The prospective approach to forecasting is closely connected with prediction, dating back to a tradition primarily concerned with building models that define causal relationships of scientific and technological developments, and with sketching probabilistic scenarios about the future. Nowadays, future developments are increasingly understood as being a systemic outcome of multiple factors and decisions. This means that political and social elements must be taken into account, rather than just obeying technical issues. Flexibility is gained by emphasizing the importance of combining results from various methods, also reducing the deterministic character traditionally associated with forecasting (Salles-Filho et al., 2001).

Some traditional forecasting tools may be appropriate under given conditions in stable economies. However, when facing volatile periods of economic crisis and turbulent environments, as with many countries in recent decades, quantitative models of forecasting alone lose value. Another constraint arises when dealing with emerging and rapidly changing industries, such as information technology and biotechnology, since results can be seemingly unexpected. Thanks to the advent of new information technologies, along with current renewable energies, smart grids, and cloud computing (to name a few), the creation of more elaborated models based in multiple variables has helped researchers to reduce errors previously associated with foresight.

2.2 Foresight

The foresight approach is often confused with other future-oriented activities such as forecasting, future studies, and strategic planning. The term should not be confused with forecasting, the latter which tends to focus its assumptions on how the future will turn out. Forecasting scholars also seek accuracy in their predictions about what the world will look like at some point in the future. Foresight contrasts directly with forecasting, as foresight is a process that aims to create shared visions of the future that will be supported through actions taken in the present. Thus, foresight does not seek to only predict the future, but also to get involved in creating it (UNIDO, 2005).

Foresight thus includes both qualitative and quantitative means for monitoring clues and indicators of trends and their development. These are best and most useful when directly linked to policy analysis and its implications. In this way, the foresight approach helps policy makers prepare for future opportunities (Zackiewicz & Salles-Filho, 2001).

Technological foresight assumes a dynamic reference system. This emerged in the conceptual development of evolutionary economics in the early 1980s. Combined with this way of thinking, the practice of foresight leads to interactions under consideration during a chaotic period of change. Thus, it can be used to promote the flow of knowledge among various social actors as a way to establish conflict moderation (Zackiewicz & Salles-Filho, 2001).

Foresight involves an explicit recognition that technological and scientific developments depend on choices made by actors in the present. In other words, they are not determined only by some intrinsic logic, nor do they happen independently, or randomly. These developments constitute a social process that is shaped by complex interactions among research institutes, universities, companies, governments, etc. It is a social process that, in the language of evolutionary economics, follows "trajectories", which give a sense of direction and irreversibility to advances in scientific and technological knowledge. Foresight aims to try to anticipate advancements and new positioning as a way of influencing the orientation of technological paths. In evolutionary terms, foreside focuses on moving ahead, ensuring the competitiveness and survival of research institutions and, by extension, their end users.

It should be noted that technological foresight is considered as a process and not just a set of techniques. It focuses on creating a better understanding about possible future developments and the forces that seem to shape them. Technological foresight also suggests that the future cannot be scientifically demonstrated from basic assumptions (the central point is to address the chances of development and the options for action at present), and that not passive, but rather active behavior towards the future is expected for positioning.

The literature offers several methods and approaches for exploring the future. Miles and Keenan (2003 as cited in UNIDO, 2005) cite four main groups of methods for thinking about the future: subject identification, extrapolative approach, creative approach, and prioritization approach. In this paper, we use the creative approach, focussing on the construction of future scenarios.

2.3 Construction of future scenarios

According to Schwartz (2000), scenarios are stories about how the world can become tomorrow, that can help us recognize and adapt to changes in our environment. The basic purpose of scenario creation is to explore 'alternative futures' that enable a better understanding of the change process (Tydeman, 1987).

Scenarios are tools for improving decision-making that have possible future environments as a background. They should not be treated as predictions that are capable of influencing the future. Instead, scenarios are vehicles that help people to learn about change. Scenarios offer alternative images about the future, rather than simply extrapolating on present trends. Scenario planning is about making choices today with an understanding of what might happen to their actions in the future.

The process of envisioning scenarios is often be compared to the process of writing a movie script, where the main idea is conceived, and the characters develop around a central theme. A number of questions must be considered when building scenarios: What are the driving forces? What is uncertain? What is inevitable?

A number of steps can be defined from these questions: 1) To identify the main theme; 2) To identify the main forces and environmental trends; 3) To classify the driving forces and trends according to their importance and uncertainty; 4) To select logical scenarios; 5) To add more details to the scenarios; 6) To evaluate the implications; 7) To select the main indicators and flags (UNIDO, 2005).

Scenario building provides a wealth of insights about possibilities for the future, in a way that helps participants to radically change the way they think of the future. Participants in scenario building strive to better understand the alternative needs of likely futures, and thus are able to develop better strategies in the present (UNIDO, 2005).

Another relevant feature in the scenario building process is to consider the necessary learning time for new technologies. Technology entrepreneurs often fail to predict their own growth because they do not take learning time into account and they may not see technological growth as an analogous "evolutionary" process (Schwartz, 2000). Much of the applicability of future forecasting has been seen in the area of business management in research carried out by Schwartz (2000), who elaborated a scenario planning methodology for corporate purposes.

According to Godet and Roubelat (1996, as cited in Coelho, 2003) when building a desired scenario, it cannot be the mere expression of a group's dream. The scenario must be a description of a plausible future, revealing a consistent vision that leads to account for the historical context as well as the resources mobilized by the collectivity. Thus, Kondratieff's economic waves can serve as a basis to fostering the process of building consistent scenarios, by portraying past events that allow extrapolations to future events.

3. Kondratieff's Economic Waves

In the field of economics, there are two main approaches to studying economic changes and patterns that could emerge in the form of waves, effectively, mainstream and heterodox or non-orthodox. Grinin, Korotayev and Tausch (2016) divide economic cycles studies in two. For them, orthodox scholars consider long-term economics in a 'mysterious' way with multiple answers and less consensus about effectiveness of long-term studies. In the heterodox approach, there is an attempt to focus on how economic processes can work in an effective way, by considering long-term economic growth as characterized by 'cyclical' processes. On the other hand, non-orthodox scholars considered long-term for studying cyclical process of 40-60 years, specially paying attention to the emergence of new paths. Some economists disagree with the heterodox approach, since there was no previous economic scenario to study the industrialization period. Thus, a key point in the theory's

Kondratieff's Economic Waves and Future Scenarios Planning: an approach for organizations

Marcos Ferasso and Eloisio Andrey Bergamaschi

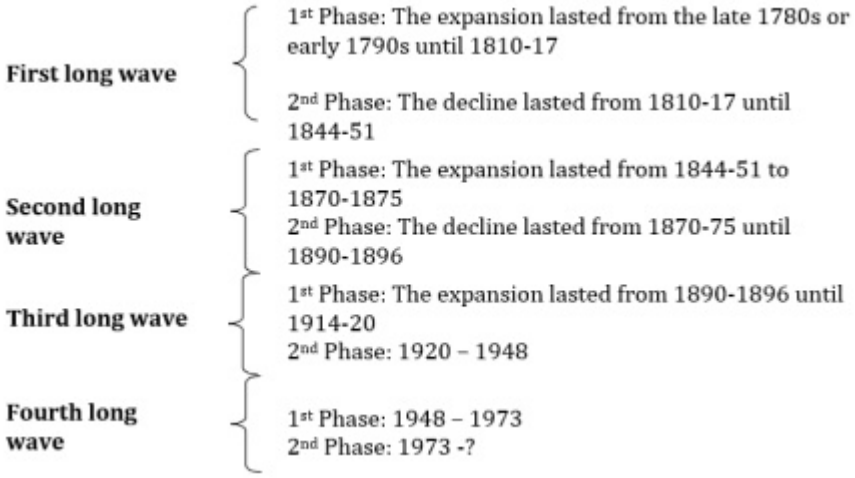

Figure 2. Kondratieff waves phases
Source: taken from Kondratieff (1935).

value is determining how long or how short Kondratieff's waves can or should become (Grinin et al., 2016).

Although the waves themselves represent patterns, there have been some attempts like Kondratieff's to determine the standards and explanations for how wave changes can occur (Grinin et al., 2016). Kondratieff conducted research focusing on studying all kinds of business cycles in market-oriented economies. Kondradieff was not the first to come up with the idea of 55-year-long waves, but he was the first to gather empirical evidence to debate and support the idea (Goldstein, 1988; Grinin et al., 2016).

Kondratieff's main interest in long waves was empirical rather than theoretical. His intention was not to constitute or lay the foundations of an appropriate theory of long waves, but rather only to reveal or demonstrate its existence based on empirical evidence from world economic history. For that, Kondratieff assembled data from several countries, seeking to examine the behavior of economic variables, such as indicators of commodity prices, iron production, imports and exports, among other things, in order to examine movements and patterns of shorter and longer waves (Kondratieff, 1935; Korotayev & Tsirel, 2010; Nefiodow & Nefiodow, 2014; Grinin, Korotayev & Tausch, 2016).

In 1935, Kondratieff stated it would be impossible to precisely determine the number of years in every changing point of long waves. Analyzing data collected seeking to support his hypothesis, Kondratieff noticed a 5-7-year discrepancy in determining the point of change. Thus, he concluded these periods could be clustered and presented according to four waves (see Figure 2).

Kondratieff's contribution in *The Long Waves in Economic Life* (1935) corresponds with what was happening around him, going through what he considered as the first and second phases of a third long wave (LW3P1 and LW3P2). According to Rangel (2005), we are permitted to extrapolate these waves by comparing with key economic facts that occurred in the period. From 1920 to 1948, the United States grew at a rate of 3% *per annum*. In comparison, Europe's growth rate was 2.4% *per annum* during the same period and is therefore consider a time of weak growth. Conversely, in the first phase of the so-called fourth wave (LW4P1) (1948-1973) the world witnessed a period of extraordinary dynamism, where the United States tripled its production.

However, 1973 seemed to mark the end of the first phase of the fourth wave (LW4P1), with a slowdown in the world economy. The poor economic performance was even more shocking as it disrupted years of particularly intense growth. After this period, development resumed, but less significantly, meanwhile symptoms arose such as higher inflation rates, increasing unemployment, and exacerbation of protectionist tendencies in many countries, which doomed further economic integration.

Likewise, the first years after the start of the second phase of the third long wave (LW3P2) in 1921, also showed economic recovery. This in turn culminated in the disaster of 1929 - 1933 and subsequently, in the great

Kondratieff's Economic Waves and Future Scenarios Planning: an approach for organizations

Marcos Ferasso and Eloisio Andrey Bergamaschi

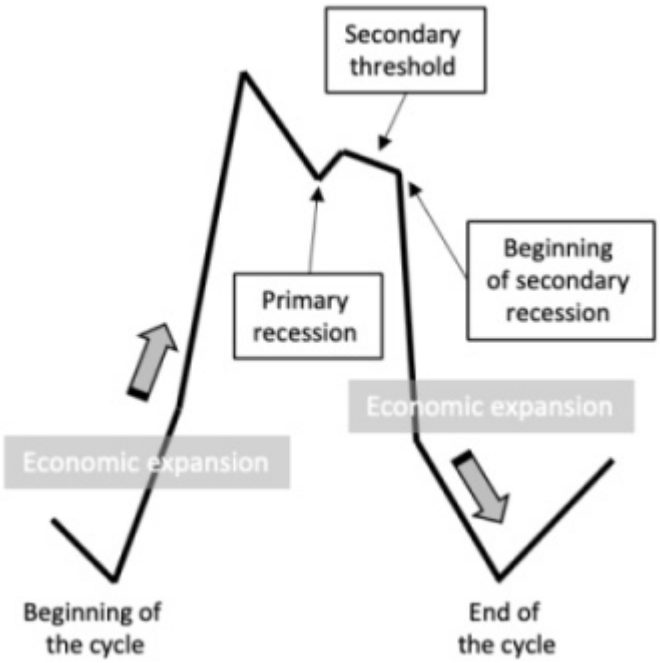

Figure 3. Four phases of Kondratieff's wave
Source: built based on Hemsi (2006: 36)

depression of (LW3P2), through past World War II.

For a quick overview of the 'cyclical vision', Kondratieff waves consist of four distinct phases, as shown in Figure 3. These are: the economic growth or expansion phase, the primary recession, the intermediate phase between the first recession and the second recession, which is called the secondary threshold, and finally, the secondary recession. Considering the identified characteristics of each phase, it is possible to anticipate changes in an economy's path. Thus, one can learn to recognize the challenges and forthcoming opportunities in each phase. This attention is summarized by Kondratieff: During the downward phase of the long waves, there are many important discoveries and inventions in the technique of production and trade, which, however, are usually only widely applied in practical economic life, when the new and persistent upward phase begins (Kondratieff, 1935 as cited in Rangel, 2005).

Figure 4 presents the idealized Kondratieff wave forecast, as well as the variation in wholesale price changes in the United States until 1980.

The beginning of the decline of each long wave can be observed through several coincidences. In 1819 - Real estate market went down; 1873 -Stock Market crash of Vienna, London, and New York; 1929 - Stock Market crash of New York, and again, in 1987, as we shall see below. Other interesting coincidences are the 25-year waves between events: 1914 - beginning of World War I; 1939 - beginning of World War II; 1964 - beginning of the Vietnam War; 1989 - fall of the Berlin Wall and consequent implosion of the Soviet Union; 2004 - Beginning of the first Iraq War.

Kondratieff's waves have since been updated by scholars, with two new waves added to his earlier vision. These new waves both refer to the digital revolution, witnessed by the ascension of Information and Communication Technologies (ICTs) that have shaped economies at global scales. The passage from fifth (LW5) to sixth waves (LW6) is marked by the financial crisis of 2007-2009. The current wave is considered the 6th Kondratieff wave, and is based on renewable energies, smart grids, cloud computing, industry 4.0, the ecosystemic perspective of innovation, circular economies, and circular business models to name a few examples. All of these changes can be related to the emergence of what some people have called "the Fourth Industrial Revolution" (Schwab, 2017), which is based on big data, mobile supercomputing, intelligent robots, and renewable energies, to name a few of characteristics of this revolution. Figure 5 presents an update by adding two waves to Kondratieff's initial graph.

Kondratieff's Economic Waves and Future Scenarios Planning: an approach for organizations

Marcos Ferasso and Eloisio Andrey Bergamaschi

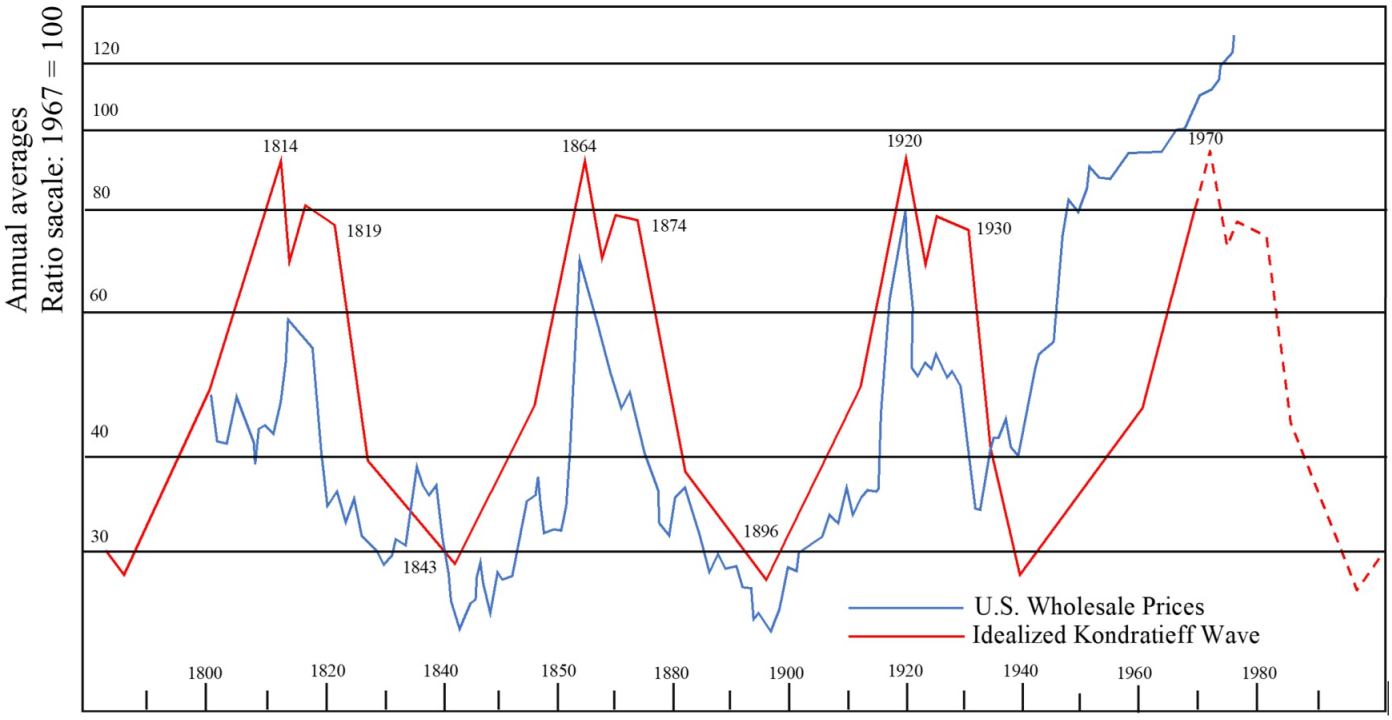

Figure 4. Kondratieff's idealized waves
Source: taken from Hemsi (2006: 37)

In a meta-inference analysis of the Kondratieff's waves and considering the two new added waves, it becomes evident that rapidly developing technologies change the time in which new economic waves are forming. In short, more rapid technological development is often responsible for accelerating economic waves. At the same time, technology is often responsible for greater emerging economic wealth, as seen in the widening continuum of the red line, compared with previous waves.

While the fifth economic wave was centered on information and communication changes, the sixth is additionally represented by revolutions in biotechnology and the healthcare domain. According to this view, we also notice the assumption that is possible to link macroeconomics with innovation. as well as technology changes for the long-term thinking and assessment (Nefiodow & Nefiodow, 2014).

According to Kondratieff (1935), long waves arise from causes that are inherent to market-oriented economies. We believe that the market-impacted behavior of these waves can therefore be used as a reference for building future scenarios. They can assist in portraying past historical series and indicate potential general directions of events, based on extrapolating recent and current behaviors to future trends.

4. Building the Edge of Future Scenarios and Kondratieff's Waves

We believe that future scenarios can be used constructively in combination with Kondratieff's waves. The long waves are meant to identify a pattern, so that it may help in the construction of possible scenarios. Rangel (2005) believes it is possible to imagine extrapolations from Kondratieff's time, according to subsequent data, thus revealing a fifth long wave, and more recently, the beginning of a sixth wave.

However, the evidence of economic waves lasting approximately fifty-five years came at an earlier time when data collection and communication was limited, and prior to computer use. In Rangel's (2005) approach, the impact of new ICTs is not shown in the waves' behavior. Nevertheless, since then, access to new technologies has allowed the spread of knowledge on a scale and speed never imagined before. Knowledge diffusion has thus had a direct and meaningful impact on social and economic patterns on a global scale.

Kondratieff's Economic Waves and Future Scenarios Planning: an approach for organizations

Marcos Ferasso and Eloisio Andrey Bergamaschi

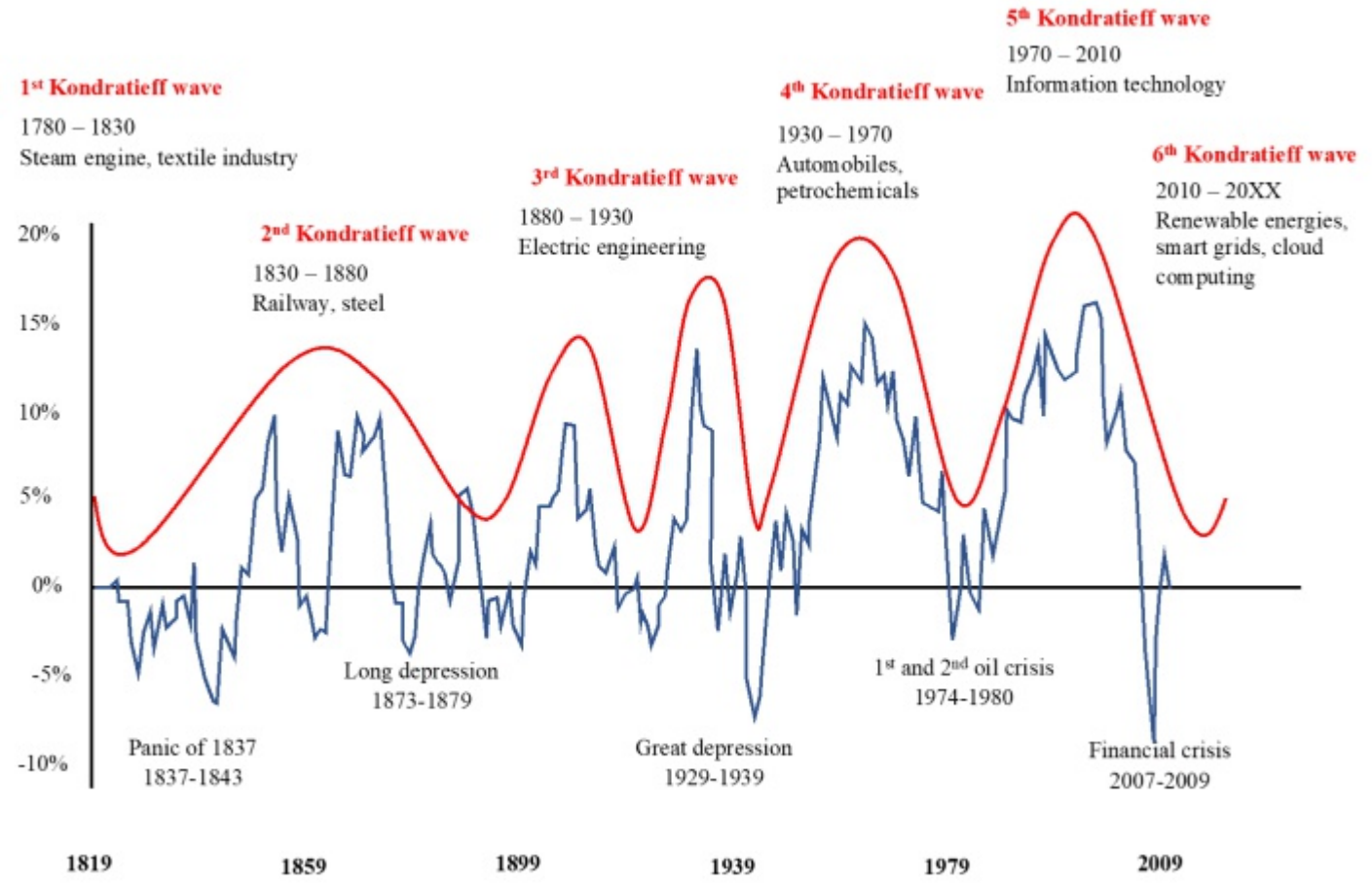

Figure 5. Kondratieff's waves updated
Source: taken from Posch and Bruckner (2017: 112)

Following the trends, we may assume that long economic waves also reduce in their duration period. In other words, the waves are occurring in a shrinking time frame. In this sense, the rapid changes can permit the faster occurrence of new business or economic opportunities, as well as threats , compared with the previous waves.

Following Kondratieff's pattern, we have left the fifth wave, even though current technologies (see in sixth wave) have not yet changed the duration. As a result, many questions arise. What are some of the challenges, opportunities and threats in the current sixth wave, according to an extrapolation of Kondratieff's model? What scenarios can be constructed from this hypothesis? Should we prepare for a possible war? What is the expected behavior of the financial markets? Are we about to collapse on a 10-15-year horizon? Considering various technological pathways, what were the innovations to be developed at the end of the sixth wave (Figure 5)? Are these innovations being widely used in the expansion phase of the sixth wave? What impact would more widely adopting these technologies have on the economy and society?

These and many other questions could be posed based on the hypothesis that the long Kondratieff waves do indeed accurately reflect economic data. Although Figure 5 shows the fifth and sixth Kondratieff's waves (Nefiodow & Nefiodow, 2014), these two differ from the pattern previously identified and shown in Figure 4. Beyond Kondratieff's waves model, we need to focus on the pattern identified by other scholars. Thus, Kondratieff's waves can contribute to technological assessments of organizations through time by considering technological directions and pathways.

5. Conclusion

The purpose of this paper has been to highlight the

Kondratieff's Economic Waves and Future Scenarios Planning: an approach for organizations *Marcos Ferasso and Eloisio Andrey Bergamaschi*

contribution Kondratieff's theory of long economic waves can provide to help elaborate future scenarios. The authors believe it can be used to consider the social, economic, and technological effects that these waves have presented throughout history.

The study of long waves allows us to identify macro-level trends of events. The practical challenge in application is how to possibly use these elements in the process of building future scenarios. The study of long economic waves does not presuppose a certain future to come, but rather can indicate possible signs based on empirical evidence from past events. As Kondratieff noted, the causes for occurring waves are inherent to the conventional market-oriented economic system (in Kondratieff's time). In today's resource-based economic thinking, based on a post-scarcity world, with the introduction of current characteristics, such as Industry 4.0, cryptocurrencies, and circular economies, it may be useful to consider the shrinking of Kondratieff's waves to predict what could be the waves emergence and when they would occur.

Through this reflection, we conclude that, although there is a close relation between thematic studies of the future, and predictions about economic behavior in Kondratieff's wave model, we still need to broaden our current understanding about the relation between long economic waves and their impact on the construction of future scenarios.

With the scope established, this article has the following limitations. Kondratieff's approach is considered as non-orthodox or heterodox in economics of planning future economic scenarios. Although we are not determining a 'one model fits all' view with this research, we are also not proposing an approach that leads only to certain results, noting the criticism of this by Nefiodow and Wilenius (2017). Thus, this manuscript stressed a basic need for better preparing decision makers for taking a long-path approach when dealing with scenario planning.

Finally, we would recommend experimentation with future scenario planning in conjunction with Kondratieff's economic waves for organizations devoted to technological forecasting. The consideration of Kondratieff's waves can contribute to scenario planning in technological assessment by providing possible directions for technological development.

Acknowledgements

Marcos Ferasso would like to thank the anonymous reviewers and TIM Review editors for their insightful suggestions that improved this manuscript, and to Sandro Nystrom Lozekam for his support in text revision.

References

Blair, P. 1994. Technology assessment: current trends and the myth of a formula. *Federation of American Scientists*. https://ota.fas.org/technology_assessment_and_congress/blair/

Castro, A.M.G. & Lima, S.M.V. 2001. *Curso de capacitação de equipes para estudos prospectivos de cadeias produtivas industriais*. Brasilia: MDIC/STI.

Coates, J. 2003. Why Study the Future? *Research Technology Management*. 2003.

Coelho, G.M. 2003. Prospecção tecnológica: metodologias e experiências nacionais e internacionais. Rio de Janeiro: *INT/Finep/ANP Projeto CT-Petro Tendências Tecnológicas*. http://www.davi.ws/prospeccao_tecnologica.pdf

Cornish, E. 2004. *Futuring: The exploration of the future*. Maryland: World Future Society.

FOREN, Foresight for Regional Development Network. 2001. *A practical guide to regional foresight*. Edited by JRC-IPTS, PREST, CM International, Sviluppo Italia.

Freeman, C. & Perez, C. 1998. Structural crises of adjustment: business cycles and investment behaviour, In: Dosi, G. (Org.). *Technical Change and Economic Theory*. London: Pinter Publishers: 38-66.

Goldstein, J.S. 1988. *Long Cycles: Prosperity and War in the Modern Age*. Yale University Press: New Haven and London.

Grinin, L., Korotayev, A., & Tausch, A. 2016. Kondratieff waves in the world system perspective. In *Economic Cycles, Crises, and the Global Periphery*, Springer, Cham: 23-54.

Hemsi, R. 2006. Previsão de Inovação Tecnológica e Ciclos Econômicos: uma abordagem histórica. *Revista de Economia Política e História Econômica*, v. 03, n. 5: 31-43. https://sites.google.com/site/rephe01/rephe05textohemsi.pdf

Knorr, K. E., & Verba, S. 2019. *International System: Theoretical Essays* (Vol. 5539). Princeton University Press.

Kondratieff's Economic Waves and Future Scenarios Planning: an approach for organizations *Marcos Ferasso and Eloisio Andrey Bergamaschi*

Kondratieff, N. 1935. The Long Waves in Economic Life. *The Review of Economic Statistics*, v. 17, n. 6: 105-115.

Korotayev, A. V., & Tsirel, S. V. 2010. A spectral analysis of world GDP dynamics: Kondratieff waves, Kuznets swings, Juglar and Kitchin cycles in global economic development, and the 2008–2009 economic crisis. *Structure and Dynamics*, 4(1).

Masini, E. & Samset, K. 1975. Recommendations of the WFSF General Assembly. *WFSF Newsletter*, June: 15.

MDIC/STI. 2001. *Programa Brasileiro de Prospectiva Tecnológica Industrial*: Plano de ação.

Miles, I., Keenan, M. & Kaivo-Oja, J. 2002. *Handbook of knowledge society foresight*. Manchester: Prest.

Nefiodow, L. A. & Wilenius, M. 2017. *Patterns of the future: Understanding the next wave of global change*. World Scientific.

Nefiodow, L. A., & Nefiodow, S. 2014. *The sixth Kondratieff: The new long wave in the global economy*. Amazon.

Posch, Gerhard & Bruckner, Jürgen. 2017. *Schweißtechnik im Zeichen von Internet of Things und Industrie 4.0. Schweiss- und Prüftechnik*. v. 70: 112-121.

Rangel, I. 2005. *Ignácio Rangel: obras reunidas*. Rio de Janeiro: Contraponto.

Salles-Filho, S.L.M., Bonacelli, M. & Mello, D. 2001. *Instrumentos de apoio à definição de políticas em biotecnologia*. Brasília: MCT; Rio de Janeiro: FINEP.

Schwab, K. 2016. *The fourth industrial revolution*. Geneva: World Economic Forum.

Schwartz, P. 2000. *A Arte da Visão de Longo Prazo: Planejando o futuro em um mundo de incertezas*. São Paulo: Best Seller.

Tydeman, J. 1987. *Futures Methodologies Handboo*k. Canberra: Australian Govt. Pub. Service for Commission for the Future.

UNIDO. 2005. *Technology Foresight Manual*. Vienna. http://www.research.gov.ro/img/files_up/1226911327TechFor_1_unido.pdf

Zackiewicz, M. & Salles-Filho, S. 2001. Technological foresight: um instrumento para política científica e tecnológica. *Parcerias Estratégicas*, v. 6, n. 10, pp.144-161.

About the Authors

M. Ferasso earned his Bachelor Diploma in Management from University of the West of Santa Catarina (Brazil) in 2002, his Specialization Diploma in Business Management from UNOESC (Brazil) in 2005, his Specialization Diploma in Local Development from International Labour Organization/United Nations (Italy) in 2006, earned his M.Sc. in Management from UFRGS (Brazil) in 2009, with an exchange period as visiting researcher at Euromed-Marseille Ecole de Management (France), and earned his Ph.D. in Management from Federal University of Parana (Brazil) in 2018, with an exchange period as visiting researcher at Forsyth Technical Community College (USA). He concluded his first Postdoctorate at Meridional Faculty —IMED (Brazil) and the second at KEDGE Business School — Marseilles (France). He is currently Assistant Professor at Unochapeco University (Brazil).

E.A. Bergamaschi earned his Bachelor Diploma in Business Management and Information Systems from Pontifical Catholic University of Rio Grande do Sul (Brazil) in 2002, his M.Sc. in Management from Federal University of Rio Grande do Sul (Brazil) in 2008, and his Specialization Diploma in Computer Science from Federal University of Rio Grande do Sul (Brazil) in 2010. Currently, he is Manager at SESI Innovation Institute (Brazil).

Citation: Ferasso, M. and Bergamaschi, E.A. Kondratieff's Economic Waves and Future Scenarios Planning: an approach for organizations. *Technology Innovation Management Review*, 10(2): 51-61. http://doi.org/10.22215/timreview/1327

Keywords: Future studies, Foresight, Strategic Planning, Economic waves, Kondratieff.

Examining the Relationship between Cybersecurity and Scaling Value for New Companies

Tony Bailetti and Daniel Craigen

> *"All models are wrong, but some are useful."*
>
> George Edward Pelham Box (1919 —2013),
> British statistician
> One of the great statistical minds of the 20th century

We explore the cybersecurity-scaling relationship in the context of scaling new company value rapidly. The relationship between the management of what a new company does to protect against the malicious or unauthorized use of electronic data, and the management of what a new company does to scale company value rapidly is important, but not well understood. We use a topic modelling technique to identify the eight topics that best describe a corpus comprised of 137 assertions about what new companies do to scale company value rapidly, manually examine the stability of the topics extracted from the dataset, and describe the relationship between 17 assertions about how to manage cybersecurity in new companies, and the six topics found to be stable. The six stable topics are labelled Fundraise, Enable, Position, Communicate, Innovate, and Complement. We find that of the 17 cybersecurity assertions, seven are related to Position, two to Innovate, one to Fundraise and, one to Complement. Six cybersecurity assertions were not found to be strongly related to any of the eight topics. This paper contributes to our understanding of cybersecurity in the context of a new company that scales its value rapidly, an application of topic modelling to perform small-scale data analysis, and a manual approach to examine the stability of the topics extracted by the topic modelling technique. We expect this paper to be relevant to new companies' top management teams, members of the networks upon which new companies depend for to scale company value, accelerators and incubators, as well as academics teaching or carrying out research in entrepreneurship.

Introduction

The professional literature that examines the relationship between cybersecurity and company value is scant and underdeveloped. Moreover, we were not able to find a single article published in an academic journal that examined the relationship between cybersecurity and the growth of new companies in initial stages of development.

Increasingly, the professional literature is framing cybersecurity as a business enabler or an influencer rather than an overhead cost or an innovation blocker (Bello, 2019; Blivet, 2019; Cohen, 2019; Sloman, 2018; Trott, 2019; Watson, 2019). This literature urges companies' security teams to deploy combinations of external and internal resources to create value and demonstrate that value (Trott, 2019).

The purpose of this paper is to increase our understanding of the relationship between cybersecurity (as represented by 17 assertions) and new companies that scale company value rapidly (as represented by 137 assertions, including the cybersecurity assertions).

The next sections of the paper provide a review of the literature in cybersecurity, describe the method used to explore the cybersecurity-scaling relationship, present and discuss the results, and summarize the conclusions.

Literature review

The professional literature describes the relationship between cybersecurity and growth of large businesses in several ways. These include factors such as how cyber security is represented at the board level (Trott, 2019; Watson, 2019), metrics used to demonstrate the value of

Examining the Relationship between Cybersecurity and Scaling Value for New Companies

Tony Bailetti and Daniel Craigen

cybersecurity to the business (CompTIA, 2019; Trott, 2019), customer loyalty (Cohen, 2019; Stoman, 2018), budget allocated to cybersecurity (Trott, 2019), extent to which security teams are overworked (Trott, 2019), preventative controls (Bello, 2019; Cohen, 2019), ability to anticipate sensitive activities (Trott, 2019), new territory expansion (Cohen, 2019), quality of responses to security breaches (Cohen, 2019), ability to trade-off cybersecurity and technology innovation (CompTIA, 2019), mobile employee empowerment (Bello, 2019), willingness to use third-party service providers (Blivett, 2019; Trott, 2019), quality of threat intelligence (Trott, 2019), increase trust in digital transformation (Trott, 2019), the workforce's level of expertise in cybersecurity (CompTIA, 2019), the level of security staff's skill in cybersecurity (CompTIA, 2019), and cybersecurity culture (Blivet, 2019).

The notion of "cybersecurity" has changed over time from data security, to computer security, and then to information security (Von Solms, 2013). This evolution has resulted in a strong technical engineering and computer science perspective for cybersecurity (Craigen et al., 2014; Ramirez, 2017; Soomro et al., 2016), along with an evolving perspective of what needs to be secured. At this point we believe that an understanding cybersecurity within a multidimensional (multidisciplinary) framework is now required.

In a 2018 commentary, Dennis Giever (Giever, 2018) argues that "we no longer have the luxury of allowing barriers to exist between those tasked with information technology security and those who provide physical security" and goes on to observe, more generally, that "Security has evolved into a rather complex enterprise which encompasses a wide range of fields". The literature review performed by (Soomro et al., 2016) reinforces the multidisciplinary perspective in arguing that information security needs a more holistic approach. They conclude by noting that "numerous activities of management, particularly development and execution of information security policy, awareness, compliance training, development of effective enterprise information architecture, IT infrastructure management, business and IT alignment and human resources management, had a significant impact on the quality of management of information security". Similarly, Kayworth and Whitten (2010) take the view that "information security strategy encompasses not only IT products and solutions but also organizational integration and social alignment mechanisms."

Questions have arisen as to whether cybersecurity is an enabler or a barrier to innovation. Nelson and Manick (2017) introduced a framework for evaluating the trade-offs. Based on their own literature review, they note that 10-15% of companies were above average in both innovation and cybersecurity maturity. These companies were called "secure digital innovators". Other companies were categorized as being reckless innovators (high innovation but low cybersecurity), secure conservatives (low innovation but high cybersecurity), or beginners (which were low in both). They also identified a number of factors that impact innovation and cybersecurity: the operating model and organizational structure; company culture and tensions created by cybersecurity efforts; boards of directors and their role in cybersecurity and innovation trade-off decisions; education, communication, and organizational awareness; legacy architectures; IT governance; and resource allocation.

Educational institutions are recognizing the need to complement technical competencies with nontechnical competencies. For example (Emmerson et al., 2019), the United States Naval Academy was amongst the first to develop an interdisciplinary pedagogical model that "blends technical courses such as programming and networks with nontechnical courses such as law, policy and ethics". In their program, they draw upon computer science, engineering, mathematics, psychology, law, political science, economics, and other fields, thereby providing "a holistic view of the threats, challenges and capabilities". This is something that would be missing if the focus is solely on technical knowledge.

The number of academic papers pertaining to cybersecurity has increased at a compound annual rate of 20% from 2004 to 2014 (Singer and Friedman, 2014). Yet, almost no one would claim that top management teams of new companies are more informed about the relationship between cybersecurity and scaling new company value.

Method

The objective is to better understand the relationship between the management of what a new company does to protect against the malicious or unauthorized use of electronic data, and the management of what a new company does to scale company value rapidly. We use 17 core assertions about cybersecurity (shown in Appendix A) to represent what a new company does to protect against the malicious or unauthorized use of

Examining the Relationship between Cybersecurity and Scaling Value for New Companies

Tony Bailetti and Daniel Craigen

electronic data. At the same time, we explore 137 assertions included in an inventory maintained by the SERS community (https://globalgers.org/) to represent what a new company does to scale company value rapidly.

The remainder of this section describes the four steps of the method used.

1. Developed topic model
A topic model is the best current approximation of finding K topics for a dataset with M documents and V unique words (Boyd-Graber et al., 2017).

Building on Boyd-Graber, Hu, and Mimno (2017), for this specific research study, by topic modelling we mean finding K topics for the following matrix formulation:

[M assertions x K topics] x [K topics x V unique words] ~ [M assertions x V unique words], where M equals 137 assertions and V equals 2,591, the latter which is the number of unique words used to express these assertions after 845 stopwords were excluded.

The first half of a topic model links K topics to "word piles". Thus, each topic represents a set of unique words extracted from the 137 assertions. Each topic gives higher weights to some words than others. The second half of the topic model links the K topics to individual assertions. Each assertion is about a small handful of topics, while most assertions have very low weights for most of the possible topics.

The topic-word relationship is based on how well a word fits with the topic. Words that fit a topic well will have higher weights than words that do not. The topic-assertion relationship is based on how well the topic expresses the assertion. Assertions that are expressed well by a topic will have higher weights for that topic.

We used Orange 3.24.1 (Orange, 2020) and the Latent Dirichlet Allocation (LDA) algorithm (Blei et al., 2003; Blei, 2012) to identify the latent topics that best describe the collection of 137 assertions about what a company does to scale company value rapidly.

The number of topics used to produce a topic model ranged from three to ten.

The decision on the number of topics for the final topic model was made by the authors of this paper based on a joint assessment of assertion weights per topic.

2.Determined topic stability
Four runs of the final topic model were performed. Topic stability was determined by assessing the consistency in which keywords appeared in the four runs of the final model, with topic quality assessed by the paper's authors (Xing & Paul, 2018). A topic was determined to be stable if five or more keywords appeared repeatedly in the four runs of the final model, and if the weights of the keywords on the topic were greater than 2. Topic quality was determined by the two authors.

3.Determined relationship between cybersecurity assertions and topics
A cybersecurity assertion was related to a topic if for each of the four runs the assertion loading in the topic was greater than 0.4.

4. Labelled and described topics
To label and succinctly describe each topic, we used keywords that appeared consistently in the four runs, the assertions that were related with the topic, and our background expertise.

Results

Corpus
The corpus is comprised of 137 assertions that are expressed using 2,591 words. On average, each assertion has 19 words. The assertions are included in the inventory of assertions maintained by the Scale Early, Rapidly and Securely (SERS) community. The SERS community is comprised of researchers and practitioners worldwide, who are committed to produce, disseminate, and evolve high quality resources about scaling companies (https://globalgers.org/). Each assertion is a clear and concise statement that describes an abstract company action, which can be detailed and then implemented to produce outcomes aimed at significantly and rapidly increasing the value of the new company. Each statement is transparent, traceable, and regionally inclusive.

Topic model
The authors decided that the best topic model generated by the research was the one that had eight topics. This decision was made for two reasons. First, the number of assertions that had topic loadings greater than .6 was at least three for each of the four runs of the eight-topics model. The second reason was that the topics of the eight-topic model made the most sense to the two authors given their understanding of the SERS assertions

Examining the Relationship between Cybersecurity and Scaling Value for New Companies

Tony Bailetti and Daniel Craigen

Table 1. Topics extracted and number of cybersecurity assertions related to them

	Labels of topics extracted	Description	Stable / Unstable	Number of cybersecurity assertions related
A.	Fundraise	Align returns to investors' capital with scale opportunity	Stable	1
B.	Combine	Combine resources and deploy resource combinations	Unstable	
C.	Connect	Find appropriate players to work with	Unstable	
D.	Enable	Make others successful	Stable	
E.	Position	Strengthen position among members of the network upon which company depends to scale	Stable	7
F.	Communicate	Eliminate communication barriers	Stable	
G.	Innovate	Continuously deliver innovative products and services, and improve value propositions	Stable	2
H.	Complement	Align benefits to customers, resource owners, and other key stakeholders	Stable	1

inventory, and the subject of scaling company value rapidly.

Stable topics

Table 1 provides the labels and succinct descriptions of the eight topics extracted from the collection of 137 assertions. For each topic, Table 1 shows whether the topic was stable or unstable, as well as the number of cybersecurity assertions that were related to it.

Our results suggest that six topics were stable: Fundraise, Enable, Position, Communicate, Innovate, and Complement. Two topics were deemed unstable, Combine and Connect, and were thus not included in subsequent analyses.

Of the six stable topics, four were related to cybersecurity assertions and two were not. Table 2 provides information about the cybersecurity-scaling relationship by identifying the six stable topics and the cybersecurity assertions that were related to them. Seven cybersecurity assertions were related to Position, two to Innovate, one to Fundraise, and one to Complement. In total, 11 cybersecurity assertions were related to four stable topics.

Six cybersecurity assertions were considered not related to the topics shown in Table 1 because their topic loadings were less than 0.4. Table 3 provides these uncategorized cybersecurity assertions.

Table 2. Topic and cybersecurity assertion relationships

Topic	ID	Cybersecurity assertion	Loading
A. Fundraise	A044	Develop and implement a governance model to scale, raise capital, protect against the unauthorized use of electronic resources, and leverage business ecosystems	0.49
D. Enable	N/A	N/A	N/A
E. Position	A068	Invest in company cybersecurity that improves cybersecurity of all members of the company value chain	0.87
	A067	Incorporate cybersecurity investment into scaling master plan	0.73
	A083	Operate in regions with strong cybersecurity policy and legal frameworks	0.66
	A016	Attain stakeholder trust by improving cybersecurity of the company and the players it works with	0.65
	A066	Incorporate cybersecurity in value propositions	0.53
	A009	Apply processes that continuously improve the cybersecurity of the company as well as its offers, channels and resources	0.47
	A038	Continuously train individuals in cybersecurity so as to i) improve cybersecurity operations, and ii) positively contribute to the company's cybersecurity culture	0.45
F. Communicate	N/A	N/A	N/A
G. Innovate	A102	Strengthen cybersecurity attributes of products and services compared to competitors	0.51
	A042	Deliver products and services that offer convenience, cater to customer demands, are secure and offer excellent customer experience	0.48
H. Complement	A088	Perpetuate a company culture of scaling based on a strongly held and widely shared set of beliefs that include high growth ambitions, delivering new benefits to customers, embedding in ecosystems led by fast growth companies, keeping the company and those it works with secure from cyberattacks, attracting investment, exceeding high standards, continuous improvement, experimentation, iteration, learning, and short feedback loops	0.67

Examining the Relationship between Cybersecurity and Scaling Value for New Companies *Tony Bailetti and Daniel Craigen*

Discussion

The results suggest that what a new company does to scale company value rapidly can be organized into six topics labelled Fundraise, Enable, Position, Communicate, Innovate, and Complement. The results also suggest that what a new company does to protect against the malicious or unauthorized use of electronic data is related in four ways to what it does to scale company value rapidly.

First, to strengthen its position among members of the network upon which it depends to scale, a new company can invest to continuously improve the cybersecurity of the company and of the members of its value chain; operate in regions with strong cybersecurity policy and legal frameworks; incorporate cybersecurity into value propositions; and train its employees in cybersecurity.

Second, to deliver innovative products and services and improve value propositions, a new company can strengthen the cybersecurity attributes of products and services compared to competitors and commit to delivering products and services that are secure.

Third, to align benefits to customers, resource owners, and other key stakeholders, a new company can perpetuate a culture of scaling its value based on a strongly held and widely shared set of beliefs, which includes keeping the company and those it works with secure from cyberattacks.

Fourth, to align returns to investors' capital with scaling opportunities, a new company can develop and implement a governance model that includes protecting against the unauthorized use of electronic resources.

Conclusions

The topic model results show that 11 cybersecurity assertions involving the scaling of a company's value are related to four topics: Position, Innovate, Complement, and Fundraise. Thus, what a new company does to protect itself and its partners against the malicious or unauthorized use of electronic data is related to what it does to scale company value rapidly in at least four ways. Our topic modelling reinforces the evolving professional and academic literature perspectives regarding cybersecurity as being a business enabler or influencer. The results certainly are contrary to cybersecurity being an innovation blocker.

While performing this analysis provided interesting perspectives on the cybersecurity-scaling relationship, it was a difficult path to follow. While running a topic model is fairly straightforward, to actually determine the

Table 3. Uncategorized cybersecurity assertions

A013	Arrange and apply resources from different regions early, rapidly and securely
A014	Assimilate what companies that scale early, rapidly and securely do, and apply it
A030	Communicate and demonstrate the importance the company places on the security of information acquired from and transferred between stakeholders
A033	Continuously improve company cybersecurity by i) assessment of cyber risks to company (Risk analysis); ii) implementation of cybersecurity measures (Protect); iii) rapid identification and response to cyberattacks (Monitor); and iv) reduction of cyberattack impact (Respond)
A048	Develop data analytic, cybersecurity, entrepreneurial, and technology related skills at all levels
A109	Use trusted cross border platforms which enable payments, refunds, logistics, data analytics and offer localization

optimal number of topics or which topics are stable was both labour intensive, and required judgement calls about how to make specific decisions on stability, or regarding the relationship strength of the assertions. One way forward is to develop techniques and associated automated tools that can facilitate the analysis of cybersecurity, both regarding selecting the number of topics and the topic stability analysis.

This paper increases our understanding of cybersecurity in the context of new companies that scale rapidly. The analysis showed that cybersecurity is strongly related to companies positioning themselves within networks for which the company is dependent for scaling, is an important component of company innovation, has linkages to fundraising, and supports the aligning of benefits to company stakeholders.

Dedication

Dan Craigen dedicates this paper to his late wife Elizabeth (Liz) Chung-Kin Chen-Craigen and to Dan and Liz's two daughters, Ailsa and Cailin, for their strength and encouragement.

Acknowledgements

We wish to sincerely thank Professors Michael Weiss and Stoyan Tanev of Carleton University's Technology Innovation Management program, Eduardo Bailetti, CEO of ScaleCamp, and Rahul Yadav, a graduate student in the Technology Innovation Management program, for their various contributions to this paper.

References

Bello, P. 2019. How cybersecurity accelerates business growth. *HelpNetSecurity*. October 21. https://www.helpnetsecurity.com/2019/10/21/cybersecurity-accelerates-business-growth/

Blei, D.M., Ng, A.Y. and Jordan, M.I. 2003. Latent dirichlet allocation. *Journal of Machine Learning Research*, 3 (Jan): 993-1022.

Blei, D.M., 2012. Probabilistic topic models. *Communications of the ACM*, 55(4): 77-84.

Blivet, C. 2019. *Why businesses need to rethink cyber security as a business priority.*

Boyd-Graber, J., Hu, Y. and Mimno, D., 2017. Applications of topic models. *Foundations and Trends® in Information Retrieval*, 11(2-3): 143-296.

Carney, J. 2011. Why integrate physical and logical security. *CISCO white paper.* https://www.cisco.com/c/dam/en_us/solutions/industries/docs/gov/pl-security.pdf

Cohen, P. 2019. Why cybersecurity is a business enabler. *F-Secure*, July 3. https://blog.f-secure.com/why-cyber-security-is-a-business-enabler/

Craigen, D., Diakun-Thibault, N., & Purse, R. 2014. Defining Cybersecurity. *Technology Innovation Management Review*, 4(10): 13-21. http://doi.org/10.22215/timreview/835

Emmerson, T., Hatfield, J.M., Kosseff, J. and Orr, S.R. 2019. The USNA's interdisciplinary approach to cybersecurity education. *Computer*, Volume 52, Issue 3, March.

Giever, D. 2018. Commentary: An argument for interdisciplinary programs in cybersecurity. *International Journal of Cybersecurity Intelligence & Cybercrime*, Volume 1, Issue 1.

Hampson, R. 2019. Making money from cyber security. *ETF Stream*. September 25. https://www.etfstream.com/feature/9262_making-money-from-cyber-security/

Kayworth, T. and Whitten, D. 2010. Effective information security requires balance of social and technology factors. *MS Quarterly Executive*, 9(3): 163-175.

Nelson, N. and Manick, S. 2017. Studying the tension between digital innovation and cybersecurity. *3rd International Conference on Information Systems Security and Privacy*, February. https://aisel.aisnet.org/amcis2017/InformationSystems/Presentations/31/

Orange, 2020. http://orange.biolab.si/widget-catalog/text-mining/topicmodelling-widget/ Accessed February 25, 2020.

Ramirez, R.B. 2017. Making cybersecurity interdisciplinary: recommendations for a novel curriculum and terminology harmonization. *Thesis, Master of Science in Technology and Policy*, MIT.

Singer, P.W. and Friedman, A. 2014. *Cybersecurity and Cyberwar: What everyone needs to know.* Oxford University Press.

Sloman, C. 2018. Reframing cybersecurity as a business enabler. *Innovation Enterprise*, April 18. https://channels.theinnovationenterprise.com/articles/reframing-cybersecurity-as-a-business-enabler

Softlanding. Accessed December 30, 2019. https://www.softlanding.ca/about-Softlanding/resources/blog/why-businesses-need-rethink-cyber-security-business-priority

Soomro, Z.A., Shah, M.H., Ahmed, J. 2016. Information security management needs a more holistic approach: a literature review. *International Journal of Information Management*, 36(2): 215-225, April.

Examining the Relationship between Cybersecurity and Scaling Value for New Companies *Tony Bailetti and Daniel Craigen*

Trott, D. 2019. Making Security an Enabler by Delivering Business Outcomes. *IDC*, May. https://www.orange-business.com/en/library/analyst-report/orange-cyberdefense-infobrief

Von Solms, R., and van Niekerk, J. 2013. From information security to cyber security. *Computers & Security*, Volume 38: 97-102.

Watson, R. 2019. How embracing cybersecurity can help your company's growth strategy. *EY*. July 25. https://www.ey.com/en_gl/advisory/how-embracing-cybersecurity-can-help-your-companys-growth-strategy

Xing, L. and Paul, M.J. 2018. Diagnosing and improving topic models by analyzing posterior variability. In *Thirty-Second AAAI Conference on Artificial Intelligence*, April.

About the Authors

Tony Bailetti is an Associate Professor in the Sprott School of Business and the Department of Systems and Computer Engineering at Carleton University, Ottawa, Canada. Professor Bailetti is the past Director of Carleton University's Technology Innovation Management (TIM) program. His research, teaching, and community contributions support technology entrepreneurship, regional economic development, and international co-innovation.

Mr. Craigen is the community and project manager with the Technology Innovation Management Program, Carleton University. Formerly, he was the Director of Carleton University's Global Cybersecurity Resource (GCR) (https://www.cugcr.ca) and was the founding president of Global EPIC (https://www.globalepic.org). Mr. Craigen was a senior science advisor with the Government of Canada for 12-years and President of ORA Canada, a company that focused on high assurance technologies and distributed its technology to sites in 65-countries. Mr. Craigen was the Chair of two NATO research task groups ("Dual use of high assurance technologies" and "Validation, verification and certification of embedded systems.") Mr. Craigen obtained a B. Sc (Honours Math) and an M. Sc from Carleton University.

Citation: Bailetti, T. and Craigen, D. 2020. Examining the Relationship Between Cybersecurity and Scaling Value for New Companies. *Technology Innovation Management Review*, 10(2): 62-70. http://doi.org/10.22215/timreview/1329

Keywords: Cybersecurity, scaling company value, topic model stability, scaling initiatives.

Examining the Relationship between Cybersecurity and Scaling Value for New Companies

Tony Bailetti and Daniel Craigen

Appendix A. Collection of 17 cybersecurity assertions

Cybersecurity Assertions	
A009	Apply processes that continuously improve the cybersecurity of the company as well as its offers, channels and resources
A013	Arrange and apply resources from different regions early, rapidly and securely
A014	Assimilate what companies that scale early, rapidly and securely do, and apply it
A016	Attain stakeholder trust by improving cybersecurity of the company and the players it works with
A030	Communicate and demonstrate the importance the company places on the security of information acquired from and transferred between stakeholders
A033	Continuously improve company cybersecurity by i) assessment of cyber risks to company (Risk analysis); ii) implementation of cybersecurity measures (Protect); iii) rapid identification and response to cyberattacks (Monitor); and iv) reduction of cyberattack impact (Respond)
A038	Continuously train individuals in cybersecurity so as to i) improve cybersecurity operations; and ii) positively contribute to the company's cybersecurity culture
A042	Deliver products and services that offer convenience, cater to customer demands, are secure and offer excellent customer experience
A044	Develop and implement a governance model to scale, raise capital, protect against the unauthorized use of electronic resources, and leverage business ecosystems
A048	Develop data analytic, cybersecurity, entrepreneurial, and technology related skills at all levels
A066	Incorporate cybersecurity in value propositions
A067	Incorporate cybersecurity investment into scaling master plan
A068	Invest in company cybersecurity that improves cybersecurity of all members of the company value chain
A083	Operate in regions with strong cybersecurity policy and legal frameworks
A088	Perpetuate a company culture of scaling based on a strongly held and widely shared set of beliefs that include high growth ambitions, delivering new benefits to customers, embedding in ecosystems led by fast growth companies, keeping the company and those it works with secure from cyberattacks, attracting investment, exceeding high standards, continuous improvement, experimentation, iteration, learning, and short feedback loops
A102	Strengthen cybersecurity attributes of products and services compared to competitors
A109	Use trusted cross border platforms which enable payments, refunds, logistics, data analytics and offer localization

Author Guidelines

These guidelines should assist in the process of translating your expertise into a focused article that adds to the knowledge resources available through the Technology Innovation Management Review. Prior to writing an article, we recommend that you contact the Editor to discuss your article topic, the author guidelines, upcoming editorial themes, and the submission process: timreview.ca/contact

Topic

Start by asking yourself:

- Does my research or experience provide any new insights or perspectives?
- Do I often find myself having to explain this topic when I meet people as they are unaware of its relevance?
- Do I believe that I could have saved myself time, money, and frustration if someone had explained to me the issues surrounding this topic?
- Am I constantly correcting misconceptions regarding this topic?
- Am I considered to be an expert in this field? For example, do I present my research or experience at conferences?

If your answer is "yes" to any of these questions, your topic is likely of interest to readers of the TIM Review.

When writing your article, keep the following points in mind:

- Emphasize the practical application of your insights or research.
- Thoroughly examine the topic; don't leave the reader wishing for more.
- Know your central theme and stick to it.
- Demonstrate your depth of understanding for the topic, and that you have considered its benefits, possible outcomes, and applicability.
- Write in a formal, analytical style. Third-person voice is recommended; first-person voice may also be acceptable depending on the perspective of your article.

Format

1. Use an article template: .doc .odt
2. Indicate if your submission has been previously published elsewhere. This is to ensure that we don't infringe upon another publisher's copyright policy.
3. Do not send articles shorter than 2000 words or longer than 5000 words.
4. Begin with a thought-provoking quotation that matches the spirit of the article. Research the source of your quotation in order to provide proper attribution.
5. Include an abstract that provides the key messages you will be presenting in the article.
6. Provide a 2-3 paragraph conclusion that summarizes the article's main points and leaves the reader with the most important messages.
7. Include a 75-150 word biography.
8. List the references at the end of the article.
9. If there are any texts that would be of particular interest to readers, include their full title and URL in a "Recommended Reading" section.
10. Include 5 keywords for the article's metadata to assist search engines in finding your article.
11. Include any figures at the appropriate locations in the article, but also send separate graphic files at maximum resolution available for each figure.

Issue Sponsor

Academic Affiliations and Funding Acknowledgements

Technology Innovation Management (TIM; timprogram.ca) is an international master's level program at Carleton University in Ottawa, Canada. It leads to a Master of Applied Science (M.A.Sc.) degree, a Master of Engineering (M.Eng.) degree, or a Master of Entrepreneurship (M.Ent.) degree. The objective of this program is to train aspiring entrepreneurs on creating wealth at the early stages of company or opportunity lifecycles.

The TIM Review is published in association with and receives partial funding from the TIM program.

SCALE EARLY RAPIDLY AND SECURELY (SERS)

The TIM Review team is a key partner and contributor to the Scale Early, Rapidly and Securely (SERS) Project: https://globalgers.org/. Scale Early, Rapidly and Securely (SERS) is a global community actively collaborating to advance and disseminate high-quality educational resources to scale companies.

The SERS community contributes to, and leverages the resources of, the TIM Review (timreview.ca). The authors, readers and reviewers of the TIM Review worldwide contribute to the SERS project. Carleton University's Technology Innovation Management (TIM) launched the SERS Project in 2019.

We are currently engaged in a project focusing on identifying research and knowledge gaps related to how to scale companies. We are inviting international scholars to join the team and work on shaping Calls for Papers in the TIM Review addressing research and knowledge gaps that highly relevant to both academics and practitioners. Please contact the Editor-in-Chief, Dr. Stoyan Tanev (stoyan.tanev@carleton.ca) if you want to become part of this international open source knowledge development project.