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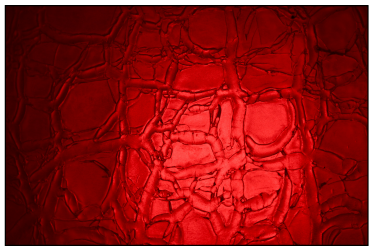

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Innovation for Local and Global Impact

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

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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.

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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: Innovation for Local and Global Impact

Stoyan Tanev, Editor-in-Chief

Gregory Sandstrom, Managing Editor

Welcome to the August 2019 issue of the Technology Innovation Management Review. This issue has a special significance since it signals the formation of a new Managing Editorial Board, including Dr. Stoyan Tanev as Editor-in-Chief and Dr. Gregory Sandstrom as Managing Editor. The TIM Review journal also has anew Board of Associate Editors and International Advisory Board. It is our pleasure to take over the editorship from Chris McPhee who, after 9 years of successfully driving the journal to where it is now, has taken on an innovation management role with Agriculture and Agri-Food Canada's Living Laboratories Initiative.

The August issue includes papers presented at ISPIM Connects Ottawa, a three-day event held in Ottawa, Canada, from April 7—10, 2019. ISPIM Connects Ottawa brought together world-renowned innovation managers, researchers, and business and thought leaders to share insights on specific local and global innovation challenges as well as general innovation management topics. The TIM Review and its associated academic program at Carleton University, the TIM Program (timprogram.ca), were proud to be the local hosts of the event in collaboration with the International Society for Professional Innovation Management (ISPIM; ispiminnovation.com) and local partners.

The topic of the ISPIM Connects Ottawa Conference was Innovation for Local and Global Impact with a focus on three challenges: scaling start-ups, adopting AI and analytics, and innovating with Government. The articles included in this issue focus on various topics related to entrepreneurship and innovation. For example, the paper by Vyas and Vyas, “Human capital, its constituents, and entrepreneurial innovation,” summarizes the results of an empirical study based on data about over 200,000 businesses provided in the Global Entrepreneurship Monitor’s (GEM) Adult Population Surveys (APS) from 2005 to 2011 in 96 countries. The paper explains the failure of previous research to extend human capital theory to innovation. The reason for the failure is found due to overlooking the conflicting influences and interplay of education and experience. The authors present a conceptual and empirical case against the use of work experience as a constituent of human capital. Their hierarchical exploration of innovation antecedents shows that, at the individual level, being young and recently educated are significant predictors of innovation. At the societal level however, national wealth dampens the negative effect of age on innovation and accentuates the positive effect of education.

The paper by Muegge and Reid “Elon Musk and SpaceX: A case study of entrepreneuring as emancipation” employs a theoretical lens to explain and interpret the entrepreneuring activities of Elon Musk that led to the launch and growth of SpaceX. The authors apply an event study approach that combines case methods and process theory methods using publicly-available sources to develop six examples of seeking autonomy, seven examples of authoring, and four examples of making declarations– the three core elements of the emancipation perspective on entrepreneuring. The paper contributes to entrepreneurship theory and practice by adding to the corpus of descriptive case studies that examine entrepreneuring as an emancipatory process. The key contribution of the paper is to demonstrate the emancipation perspective's value as an organizing framework that accommodates wealth-creation, hubris, bricolage, effectuation, and other perspectives on entrepreneurship and innovation, as partial and complementary explanations of the motivations and processes behind entrepreneuring activities.

Gordon, Rohrbeck and Schwarz's paper, “Escaping the ‘faster horses’ trap: Bridging strategic foresight and design-based innovation”, explores how methods from the strategic foresight field may advance design thinking. The study offers a comparison of representative models from each field and shows how they may be assembled together to shape a foresight-informed design-based innovation approach. The suggested framework incorporates academically and practically validated strategic foresight processes into design thinking, while also respecting the integrity of the design thinking model as is, thus adding to it rather than seeking to revise it. The authors discuss the benefits of strategic foresight, arguing that it takes design thinking beyond reliance on user observation, and therein helps to mitigate its vulnerability to significant or unforeseen contextual changes.

The paper by Omar Valdez-De-Leon “How to develop a digital ecosystem —a practical framework” provides a

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literature review and an analysis of empirical observations from expert surveys and interviews. He suggests a practical framework for both established organizations and entrepreneurs who are interested to better understand, plan, and navigate the new paradigm of digital ecosystems. The framework has three main elements —platform, market expectation and network effects, and six enablers —application programming interfaces (APIs), communities, spearhead products and services, support functions, revenue model and governance. The implementation of the six enablers allows for flexibility depending on the context, the maturity of the ecosystem, and the strategy being pursued. The framework will be valuable to practitioners who can apply it as a guiding tool when developing their digital ecosystem strategies, be it as an ecosystem leader, or as a participant in an existing ecosystem.

Weiss and Muegge's paper "Conceptualizing a new domain using topic modeling and concept mapping: A case study of managed security services for small businesses" shows how topic modeling and concept mapping can be used to conduct a literature review in a new domain. The paper makes two contributions. First, it uses topic modeling to map out the literature in the new domain. Topic modeling provides an alternative to manual clustering of articles and enables the identification of non-obvious connections between ideas expressed in a collection of articles. Second, it identifies the underlying concepts in the new domain, as well as their relationships by creating a concept map from the extracted topics. As a case study, the paper reviews the recent literature at the intersection of managed security services and small businesses, and explores how elements of the managed security services concept apply to small businesses. More specifically, the paper highlights a crucial shift from operations to risk considerations when small businesses outsource their security. The key contribution is to suggest complementarity between concept mapping and topic modelling analysis.

For other future issues, we are accepting general submissions of articles on technology entrepreneurship, innovation management, and other topics relevant to launching and growing technology companies and solving practical problems in emerging domains. Please contact us (timreview.ca/contact) with potential article topics and submissions, and proposals for future special issues.

Stoyan Tanev, Editor-in-Chief
Gregory Sandstrom, Managing Editor

About the Editors
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.

Gregory Sandstrom is Managing Editor of the TIM Review. Former associate professor of mass media and communications at the European Humanities University and affiliated associated professor at the Social Innovations Laboratory, Mykolas Romeris University in Vilnius, Lithuania. PhD from St. Petersburg State University and the Sociological Institute of the Russian Academy of Sciences, sector on sociology of science. Postdoctoral research fellow at the Lithuanian Science Council and Autonomous National University of Mexico's Institute for Applied Mathematics and Systems. Promoter and builder of blockchain distributed ledger technology systems and digital extension services.

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Keywords: ISPIM, human capital, business models, emancipation, entrepreneurship, design thinking, strategic foresight, digital ecosystems, topic modeling

Human Capital, Its Constituents, and Entrepreneurial Innovation: A Multi-Level Modelling of Global Entrepreneurship Monitor Data

Vijay Vyas and Renuka Vyas

> *"Innovation has nothing to do with how many R&D dollars you have… It's not about money. It's about the people you have."*
>
> Steve Jobs (1955–2011),
> Co-founder of Apple and Pixar

In this study, we use multi-level modelling to analyze data of over 200,000 businesses in 96 countries to explain the failure of previous research to extend human capital theory to innovation. We trace this failure to, previously overlooked, conflicting influences of education and experience. The two key constituents of human capital are often used in research as innovation antecedents and present a conceptual and empirical case against the use of work experience as a constituent of human capital. Our hierarchical exploration of innovation antecedents shows that, at the individual level, being young and recently educated are significant predictors of innovation whereas, at the societal level, national wealth dampens the negative effect of age on innovation and accentuates the positive effect of education on it.

Introduction

Recently, the role of human capital in entrepreneurship has attracted substantial scholarly interest (Dimov, 2017; Dutta & Sobel, 2018; Marvel et al., 2016; Unger et al., 2011). Within the resulting literature, studies on the link between human capital and innovation have yielded counterintuitive and conflicting results (Wincent et al., 2010). Subramaniam and Youndt (2005), for instance, report that human capital is adversely related to radical innovation capability, Marvel and Lumpkin (2007) find that market knowledge is negatively influences radical innovation, and Delgado-Verde and co-authors (2016) do not find support for their proposed inverted U-shaped positive effect of human capital on radical innovation. At the same time, many studies examining this relationship report a positive link (e.g., Colombo et al., 2017; Crespo & Crespo, 2016; Kianto et al., 2017; Miguélez et al., 2011; Rupietta & Backes-Gellner, 2017).

Teixeira and Fortuna (2010) argue that, "human capital is generally poorly proxied, and measurement problems are particularly acute when it comes to this variable". We advance this argument further and clarify the cause of the conflicting findings described above. We find that education, experience, or both are often used as the building blocks of human capital and the empirical research has frequently measured the outcome of the impact of education or experience or education plus experience on innovation. However, as we show below, experience and education leverage innovation in opposite directions, therefore when the relationship between human capital and innovation is empirically tested, the outcomes turn out to be divergent. More specifically, as Table 1 shows, when human capital is articulated purely in terms of educational attainment or where experience is excluded from the calculus of its measurement, the effect of human capital on innovation is invariably positive. In contrast, when human capital is measured purely in experience terms or when experience is a part of its calculus, an analysis of its influence on innovation often yields a negative or non-significant relationship.

Work experience as human capital: The conceptual incongruity

Ostrom and Ahn (2009), observe that "All forms of capital involve the creation of assets by allocating resources that could be used up in immediate consumption to create assets that generate a potential

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flow of benefits over a future time horizon." The creation of human capital, too, thus involves diverting resources from current consumption and investing them to generate a potential flow of *future* benefits. This happens when people invest in education, training, or health or when they allot time and money to migrate to places where they hope to have better incomes and lives. All of these actions, therefore, give rise to human capital. However, when people take up employment and begin to accumulate work experience, they do it primarily to earn *immediate* benefits. This is a key difference between education and work experience, two potential enhancers of human productivity. People seek education principally for future economic benefits whereas they seek employment primarily for current benefits. Further, investment entails diversion of

Table 1. Performance influence of human capital

Source	*Human Capital Constituents*	*Performance Measures*	*Selected Relevant Results*
Subramaniam & Youndt (2005)	Knowledge, skills, and ability (KSA)	Radical innovation capability	Negative effect
Marvel & Lumpkin (2007)	Education, breadth and length of experience	Innovation radicalness	Strong effect of education, weak effect of length of experience, no effect of breadth of experience
Rodríguez-Pose & Crescenzi (2008)	Education	Regional innovation	Positive effect
Teixeira & Fortuna (2010)	Education	Total factor productivity	Substantial positive effect
Wincent et al. (2010)	Board's education and diversity	Innovative performance of network participants	Positive effect
Al-Laham et al. (2011)	Education and tenure	Patents renewal	Education has positive and tenure has negative effect
Miguelez et al. (2011)	Education	Number of patents	Positive effect
Robson, et al. (2012)	Education and experience	Engagement in innovation activities	Experience strong positive effect, education weak effect
Castellacci & Natera (2013)	Education	Innovation dynamics (ID): per capita growth (PCG)	Positive effect of secondary education on ID and of tertiary education on PCG
Belso-Martinez et al. (2013)	Education, research experience	Performance of new innovative firm	No effect
Felsenstein (2015)	Education	Regional innovation	Large positive effect
McGuirk et al. (2015)	Education, training, and others	Product, process, and service innovation	Positive effect of training
Delgado-Verde et al. (2016)	KSA	Radical innovation	Inverted U-shaped positive effect not supported
Crespo & Crespo (2016)	Education	Knowledge, technology, and creative outputs	Positive effect
Rupietta & Backes-Gellner (2017)	Education	Incremental innovation	Human capital a key component of innovation affecting configuration
Colombo et al. (2017)	Education	R&D investments	Positive effect

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resources from current consumption for future potential benefits. This happens with education but not with employment. Employment, therefore, is not investment and the work experience that it provides is not human capital. Finally, as Becker (1964) suggests, "forgone earnings are an important, although neglected cost of much investment in human capital". Forgone earnings are obvious in education. However, usually there are no forgone earnings in the process of gaining work experience. We argue that, unless we are able to trace the origin of a productive human advantage to some form of investment of resources diverted from current consumption or to some forgone earnings, what we have is not human capital. It is therefore conceptually wrong to consider work experience a constituent of human capital.

In this article, we first provide a review of literature on human capital underscoring the contribution of key pioneers of this concept. We then present our primary as well as moderating hypotheses and the conceptual and empirical logic underpinning them. Data and measures used in this work are then elaborated and variables are specified. This is followed by our rationale for using multi-level modelling as well as the details of the data analysis process. Finally, we discuss our results, highlight our contribution and spell out the limitations of this work, its future research directions, as well as its policy implications.

Literature Review: Human Capital

Though traces of human capital doctrine could be seen in Adam Smith's writing as early as 1776 (Smith, 1952), it was not until the 1960s that human capital emerged as an influential contribution to enhancements in human productivity in the economic growth process. Becker's (1964) definition of human capital, as "the knowledge, information, ideas, skills, and health of individuals" (Becker, 2002) is, essentially, not much different from its modern perception as "the characteristics possessed by… individual(s) that can yield positive outcomes for (them)" (Wright & McMahan, 2011).

Schultz and Becker contributed most to the early articulation of human capital doctrine and in estimating its contribution in the calculus of economic growth. Its basic premise was that individuals accumulate productive human capital over time by way of knowledge, skills, and expertise and investments in human capital, particularly in education, account for a significant part of economic growth (Becker, 1962, 1964; Schultz, 1960, 1961). Pioneering work on the role of human capital in economic growth was duly rewarded. Starting with Schultz and Becker, five Nobel prizes in economic sciences were awarded to scholars for their contributions in this field, with the other three going to Milton Friedman, Simon Kuznets, and Robert Solow (Sweetland, 1996).

Despite wide acceptance of the value of human capital construct in explaining economic growth, the analyst who pioneered the concept diverged on what were its precise building blocks, something which remains unchanged until now, as we have shown above. Schultz's (1961) configuration included health services, on-the-job training, education, and migration, whereas Becker (1964) included education, on the job training, information, and health. Contrary to the impression in some of the recent literature (e.g., Cao & Im, 2018; Davidsson & Honig, 2003; Marvel & Lumpkin, 2007), Becker (1962, 1964) did not include work experience as a component of human capital in his analysis (and, as stated above, neither did Schultz [1960, 1961]. Among the pioneers, Mincer (1974) was conspicuous for his inclusion of work experience as a component of human capital and, in all likelihood, was responsible for a tradition of its inclusion in it that continues until today.

We believe that, to unpick the contribution of human capital's various candidate elements in the innovation process, it is imperative that we decompose it into its key postulated constituents to better understand their individual roles in entrepreneurial innovation. Using age as a proxy for experience, we have attempted it here.

Hypothesis Development

Education and innovation

At the start of 20th century, formal education gradually began to be seen as a vital influence on innovation (Nelson & Rosenberg, 1993), and this continues to be the case. Holbrook and Clayman (2003) report that tertiary education develops the innovative skills of recipients. Leiponen (2005) shows that high educational levels complement product and process innovation. Vila and co-authors (2012) report that learning and teaching modes used in higher education develop innovation competencies. Investments in education explain a significant part of rise in total factor productivity in Portugal (Teixeira & Fortuna, 2010) as well as across the European Union (Bonin, 2017). Crespo and Crespo (2016) show that a high "level and standard of education" is linked with high innovation performance. Colombo and co-authors (2017) report that the share of employees with at least a university degree in the workforce is a significant predictor of R&D-to-Sales

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ratio. Given the evidence on the nexus between education and innovation in such a range of milieus (Arvanitis & Stucki, 2012), we argue that the premise that an entrepreneurs' education would positively influence innovation in their enterprises follows logically and naturally.

We thus hypothesize that:

> ***Hypothesis 1:*** Entrepreneur education positively influences innovation in their enterprises.

Age and innovation

The balance of evidence on the relationship between age and innovation decisively points to a negative connection. Pfeifer and Wagner (2012) record a strong adverse impact of average age on several innovation-linked indicators. Schubert and Andersson (2015) find the age of an individual to be negatively related to their innovation performance, and Arntz and Gregory (2014) show that 17% of the gap in regional innovation performance in Germany is explained by demographic aging. In a related context, Jones (2010) reports scientists' peak creative productivity in middle age, which is followed by declining performance. We found only one study (Ng & Feldman, 2013a) that positively links age with innovation-related behaviour. However, the same authors did not find such a relationship an earlier study (Ng & Feldman, 2008) or in their meta-analysis (Ng & Feldman, 2013b). These findings indicate that the evidence for a positive relationship is limited and sketchy. Furthermore, it is shown that the innovative advantage of the young lies in their higher risk tolerance (Lévesque & Minniti, 2006) and in the contemporariness of their technological skills (Ouimet & Zarutskie, 2011).

We thus hypothesize that:

> ***Hypothesis 2:*** Entrepreneur age is negatively linked with innovation in their enterprises.

National income and innovation

Despite the widely recognized causal nexus of innovation with competitiveness, growth, and economic prosperity, the potential inverse causation between current levels of national income and future innovation has not been theoretically discussed or empirically tested. We argue that the nature and direction of causality here can be deduced from the findings of works on the relationship of current levels of per capita income with future prospects of growth. Barro's (1991) finding that "higher per capita GDP is substantially negatively related to subsequent per capita (income) growth" and his more recent estimate of "conditional convergence rate around 2% per year" (Barro, 2015) indicate that highly innovative nations are likely to have slower future increases in their innovativeness. This result is also inferred from Kortum's (1997) search model, which shows that technological advances push a nation closer to the technological frontier and decrease the technological gap, ceteris paribus, diminishing its future innovation potential. Conversely, from the convergence literature, Gerschenkron's (1952) conception of "advantage of backwardness" implies that further a country stands behind the technology frontier, larger it has the scope for innovation.

We thus hypothesize that:

> ***Hypothesis 3:*** Per capita income of a country is negatively related to innovation in its enterprises.

Next, we consider moderating hypotheses.

Effect of age on the relationship between education and innovation

We argue that the ability of entrepreneurs to utilize their formal education for innovation will diminish with age on the premise that the general decline in the value of knowledge with time (Frosch & Tivig, 2007) applies to its value for innovation as well. Innovation involves the creation of new products, processes, and forms of organizations that perform better than the existing ones. We argue that the entrepreneurs' ability to innovate depends on the contemporariness of their knowledge. Up-to-date knowledge related to products, processes, and organizations is a prerequisite to conceptualize, create, and use their future and better versions. The earlier the acquisition of knowledge is, the more primeval the products, processes, and organizations are that it relates to. Frosch and Tivig (2007) find that, "engineering knowledge and, to a smaller extent, formal academic knowledge lose their innovation-enhancing effect when the labor force grows older". Further, as Simonton's (1988) work shows, the "ideations' ability — the knack to visualise a new realm of possibility by recombining knowledge —diminishes with age as the fluid intelligence falls (Kanfer & Ackerman, 2004), leading to a reduced ability of an entrepreneur to take advantage of their knowledge for innovation.

We thus hypothesize that:

> ***Hypothesis 2a:*** Entrepreneur age negatively moderates the effect of education on innovation in their enterprises.

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Effect of national wealth on relationships of age and education with innovation

Entrepreneurs' efforts to utilize their education and age-related competencies for innovation could be supported or hindered by the environments within which they operate. The national system of innovation perspective posits that, in relation to the ability of an individual to innovate, the role of "the national education system, industrial relations, technical and scientific institutions, government policies, cultural traditions and many other national institutions is fundamental" (Freeman, 1995). Innovation-enabling overarching national characteristics include the quality and extensiveness of higher education (Lundvall, 2008), the calibre of public and private research institutions (Albuquerque et al., 2015), and the value national governments place on innovation as well as their ability and preparedness to support it (Watkins et al., 2015). The potential of these innovation-enabling influences is closely connected to the levels of national wealth. Countries with high per capita income have, in general, better universities and research organizations as well as more transparent, efficient, and effective governments. As a result, other things being equal, entrepreneurs engaging in innovation in affluent countries find themselves operating in more enabling environments. They are thus able to use their education for innovation more successfully than entrepreneurs are in poorer countries. The superiority of innovation-enabling environments in wealthier countries also weakens the negative effect of age on an entrepreneurs' ability to innovate.

We thus hypothesize that:

Hypotheses 3a: Per capita national income positively moderates the effect of education on innovation.

Hypotheses 3b: Per capita national income negatively moderates the effect of age on innovation.

Data and Measurements

Data

The gross national income per capita (GNI) data for this work is taken from the Human Development Index (UNDP, 2014). The rest of the data comes from Global Entrepreneurship Monitor's (GEM) Adult Population Surveys (APS) from 2005 to 2011 in 96 countries

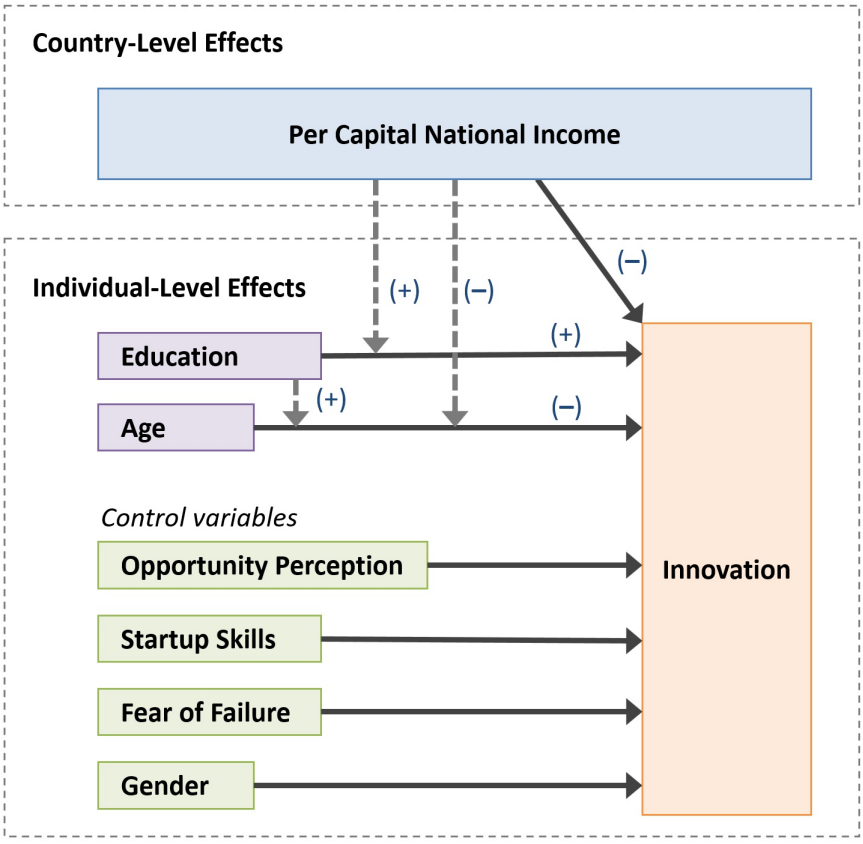

Figure 1. Conceptual model

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(Reynolds et al., 2005). GEM data is well recognized for its quality, and its use has made significant contribution to entrepreneurship research over many years (Levie et al., 2014). For the APS, a minimum of 2,000 randomly chosen adults are interviewed in each participating country in a survey commissioned by GEM's respective country teams. All consequent data is weighted by relevant demographic variables to harmonize it and make it as representative as possible of the respective countries' adult populations (Reynolds et al., 2005 provide a detailed explanation of the GEM method). The APS data constitutes a fairly representative sample of adults in surveyed countries. From this sample, 210,554 owner-managers of existing businesses are sub-sampled for analysis here. The findings are therefore generalizable to the universe of all firms in these countries (Schøtt & Jensen, 2016).

The GEM model generates multi-level data (Levie & Autio, 2008), which can be used to draw meaningful inferences only through multi-level modelling (Carson & Beeson, 2013), as we have attempted here.

Dependent variable

Innovation is measured from the data generated by the answers to three APS questions given below:

1. "Will all, some, or none of your potential customers consider this product or service new and unfamiliar?" The useable answers and related original data values (in parenthesis), vary between, all (1), some (2), and none (3).

2. "Right now, are there many, few, or no other businesses offering the same products or services to your potential customers?" The useable answers and related original data values (in parenthesis), vary between, many business competitors (1), few business competitors (2), and no business competitors (3).

3. "Have the technologies or procedures required for this product or service been available for less than a year, or between one to five years?" The useable answers and related original data values (in parenthesis), vary between less than a year (1), between one to five years (2), and longer than five years (3).

For questions 1 and 3 above, higher data values imply lower innovation. The data reversal is therefore applied to generate the data sets with higher values implying higher innovation. After confirming statistically significant positive correlations among the data sets, with two of them so modified, a new variable "Innovation" is created by adding the mean of data values for three innovation-related questions. This means that the innovation so measured covers product as well as process innovation but excludes organizational innovation.

Independent variables

Entrepreneur age is self-reported chronological age. It varies between 18 years to 64 years in APS data.

Entrepreneur education is self-reported years of formal education. It varies between 0 to 19 years in our data.

GNI is Gross national income per capita (in 2011) taken from Human Development Index (UNDP, 2014). It is expressed in thousands of Purchasing Power Parity dollars and varies between 0.715 for Malawi and 72.371

Table 2. Correlations and descriptive statistics

Correlations							
	Opport	Nofearfail	Gender	Age	Education	GNI	INNO
Opport	1						
Suskill	.139**						
Nofearfail	.111**	1					
Gender	.002	.040**	1				
Age	-.129**	-.018**	.024**	1			
Education	-.040**	.036**	.055**	-.007**	1		
GNI	-.153**	.019**	.065**	.228**	.368**	1	
INNO	.081**	.025**	-.010**	-.102**	.079**	-.039**	1
Descriptive Statistics							
Mean	.57	.74	.61	40.12	11.58	21.77	1.48
Std. Deviation	.50	.44	.49	11.65	4.63	14.6	.47
N	185106	204027	210514	210554	205883	210431	210554

** Correlation is significant at the 0.01 level (2-tailed)

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for Singapore.

Control variables

We have used four control variables for our analysis. A prerequisite for innovation is that the innovator is 'not constrained by a fear of failure' (Amabile & Khaire, 2008). We therefore expect fear of failure to be negatively related to innovation. By reversing the Fearfail variable in GEM data, we have recorded it as Nofearfail with 0 if answer is "yes" and 1 if it is "no" to the APS question "Fear of failure would prevent you from starting a business." As ability to spot opportunities is at the core of innovation (Gailly, 2018), we have included, as a control variable, Opport from the APS, which is a measure of entrepreneur's ability to "perceive good business opportunities". The APS variable Suskill, which measures an entrepreneur's knowledge and skills in starting a business, is our third control variable. We have chosen it based on the argument that knowledge and skills needed to start a new business would also be useful in introducing a new product, new service, or a new way of doing business. Though Gender as an innovation influence continues to be under-researched, particularly within entrepreneurship literature, it is now increasingly recognized as an important influence on innovation (Alsos, et al. 2012); we have therefore included it as our fourth control variable.

Random effects variable

In our multi-level model (MLM), we have used Country, in GEM data, as the random effects variable.

Correlations matrix and descriptive statistics

The correlations, means, and standard deviations of the variables involved in this nalysis are given in Table 2. Correlations of all control variables with innovation are statistically significant. All three hypothesized independent variables are also significantly correlated with innovation at $P < 0.01$, and the directions of correlations are as postulated. However, no set of independent variables are highly correlated (Pearson correlation coefficient > 0.5). This finding rules out multicollinearity. These results also show that entrepreneurs from wealthier countries are older and more educated. However, they are less innovative, indicating a more powerful combined negative influence of age and national wealth on innovation than that of education. They also reveal that the younger entrepreneurs are more educated and are more innovative. One noteworthy finding from this analysis is that, globally, woman entrepreneurs are marginally more innovative than men, and this difference is statistically significant.

Data Analysis and Results

We deploy MLM to examine the influence of entrepreneur age, education, and per capita national income of their countries on innovation with random effects of their national location through the variable Country.

Random effects model

After generating the Null model with baseline values, we first test if the variable Country has valid random effects within MLM estimation procedure. The following equation for this model postulates that observed Innovation (I) is explained by the general intercept (γ_0), the random effects of Country (μ_c) and by a random error (or unexplained variance) (ε):

$$I = \gamma_0 + \mu_c + \varepsilon$$

The results of this model are summarized in Table 3, Model 2, which show that random effects of country (μ_c) are highly significant are highly significant ($p < 0.001$), indicating, as postulated, that observed innovation varies across countries. The variable Country, therefore, can be justifiably included in the predictor model as random effects.

MLM with controls

We now use MLM to test if opportunity perception, start-up skills, no fear of failure, and gender are valid influences on innovation to be used as control variables. Level 1 (individual level) variables such as these control variables as well as the predictors with a raw metric with no meaningful zero point must be centred to have correct interpretation of results in multi-level modelling (Enders & Tofighi, 2007). As our focus is on an individual-level variable, entrepreneurial innovation, we need to deploy grand mean centring for this purpose (Carson & Beeson, 2013). We use this to centre control variables as well as to centre all predictors subsequently.

The MLM equation at this stage postulates that, in addition to the general intercept (γ_0), the random effect of country (μ_c) and the random error (ε), opportunity perception (γ_{opport}), start-up skills (γ_{suskil}), no fear of failure (γ_{nff}) and gender (γ_{gender}) explain the observed innovation further.

$$I = \gamma_0 + \gamma_{opport} + \gamma_{suskil} + \gamma_{nff} + \gamma_{gender} + \mu_c + \varepsilon$$

The results of this model, summarized in Table 3, reveal fixed effects of all control variable as well as random effects of variable Country to be highly significant ($p < 0.001$).

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Table 3. Results

Parameters	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model 5*
Regression Coefficients (Fixed Effects)					
Intercept	1.480884 -(.0010)***	1.495028 (.015093)***	1.500891 (.014957)***	1.495774 (.014558)***	1.495835 (.014542)***
Opport			.058695 (.002288)***	.051999 (.002306)***	.051395 (.002308)***
Suskill			.023829 (.003131)***	.017876 (.003159)***	.018082 (.003159)***
Nofearfail			.023855 (.002483)***	.021059 (.002494)***	.021182 (.002494)***
Gender			-.019678 (.002215)***	-(.018723 (.002225)***	-(.018720 .002226)***
GNI				-.001051 (.000929)	-.001105 (.000927)
Age				-.003110 (.000096)***	-.003146 (.000096)***
Education				.006276 (.000266)***	.006440 (.000271)***
Age*Edu					-.000012 (.000021)
GNI*Age					-.000038 (.0000071)*
GNI*Edu					.000042 (.000019)***
Variance Components (Random Effects)					
Residual (	.219925 (.000678)***	.201311 (.000621)***	.200243 (.000669)***	.197747 (.000667)***	.197699 (.000667)***
Country ()		.022057 (.003195)***	.021608 (.003135)***	.020242 (.002954)***	.020167 (.002943)***
Model Summary					
Deviance stat (-2LL)	278648.812	260512.904	221123.233	214300.657	214258.05
# of estimated parameters	2	3	7	10	13
N (Individuals)	210554	210554	179447	175698	175698
N (Countries)	96	96	96	96	96

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MLM with predictors
Now we enter our centred predictors in MLM as per the equation below:

$$I = \gamma_0 + \gamma_{opport} + \gamma_{suskil} + \gamma_{nff} + \gamma_{gender} + \gamma_{age} + \gamma_{edu} + \gamma_{NI} + \mu_c + \varepsilon$$

This brings into play age (education), and per capita national income as innovation influencing factors. The results of this model, summarized in Table 3, Model 4, show that fixed effects of all control variable as well as random effects of variable Country continue to be highly significant ($p < 0.001$). They additionally show that age and education are significant predictors of innovation. As postulated, age has a negative effect and education has a positive effect. However, they also show that per capita gross national product (GNP) is not a significant predictor of entrepreneurial innovation. This means that H1 and H2 are supported ($p < 0.001$). However, H3 is not supported.

MLM with interaction variables
Finally, we enter our interaction variables in the analysis as below:

$$I = \gamma_0 + \gamma_{opport} + \gamma_{suskil} + \gamma_{nff} + \gamma_{gender} + \gamma_{age} + \gamma_{edu} + \gamma_{NI} + \gamma_{(age*edu)} + \gamma_{(NI*age)} + \gamma_{(NI*edu)} + \mu_c + \varepsilon$$

The results of this model, summarized in Table 3, Model 5, show that fixed effects of all control variables, that of predictors, age and education, as well as random effects of variable Country continue to be highly significant. They also show that per capita GNI negatively influences the relationship of age with innovation ($p < 0.05$) and it positively influences relationship of education with innovation ($p < 0.001$), as postulated. However, it shows that age does not influence the relationship education of with innovation. This means that H3a ($p < 0.001$) and H3b ($p < 0.05$) are supported but H2a is rejected.

Local effect size
To determine the magnitude of influence captured by MLM, we use the equation below:

$$(\sigma^2 \text{ null model} - \sigma^2 \text{ Model 5}) / (\sigma^2 \text{ null model})$$

The Null model includes only the general intercept and no random effects, control variables, or predictors. The equation above therefore, captures the total effect size, which is 10%.

To know what part of this 10% variance is explained by our predictors, we use the equation below:

$$([\sigma^2 \text{ Model 3} + \tau^2 \text{ Model 3}] - [\sigma^2 \text{ Model 5} + \tau^2 \text{ Model 5}]) / ([\sigma^2 \text{ Model 3} + \tau^2 \text{ Model 3}])$$

This shows that 2% out of the total 10% variance in innovation is accounted for by the predictors.

Model fit
To check the improvements in model fit at successive stages of analysis, we compare -2 log likelihood (-2LL) ratios where smaller values are indicative of better fit of the model to the data. Subtracting -2LL deviance of Model 2 from that of Model 1, we find a positive difference of +18136 ($p < 0.001$), indicating a better fit of Model 2 than Model 1. The difference in -2LL between Model 3 and Model 2 is +39390, between Model 4 and Model 3 it is +6823, and between Model 5 and Model 4 it is +43. This means that, at each stage of analysis, the fitness of data to the model has improved.

Discussion and Conclusions
We discover that, at the individual level, being young and recently educated are significant predictors of entrepreneur innovation whereas, at the societal level, national wealth dampens the negative effect of age on innovation and heightens the positive effect of education on it. Our work, thus, extends the literature on the relationship between age and innovation by showing that younger entrepreneurs are more innovative and, by controlling for education, it establishes that this result is not as influenced by education as thought previously (Frosch, 2011).

We also find empirical support for our earlier argument that the cause of failure of previous research to extend human capital theory to innovation (Delgado-Verde et al., 2016; Marvel & Lumpkin, 2007) is due to the inclusion of experience as a measure of human capital. Our work clarifies that it is only knowledge reflected in education —and not experience, echoed by age —that positively influences innovation. This finding is consistent with a significant part of previous research (Colombo et al., 2017; Crespo & Crespo, 2016; Miguelez et al., 2011; Rupietta & Backes-Gellner, 2017; Teixeira & Fortuna, 2010).

Our interaction results show that, notwithstanding their relative higher average age, the ability of entrepreneurs in developed countries to utilize their education for innovation is enhanced by the wealth of their nations, and we argue that this "wealth effect" operates through the mechanism of differential quality of national innovation support systems (Albuquerque et al., 2015; Lundvall, 2008; Watkins et al., 2015). As a result, entrepreneurs in richer countries have better

innovation outcomes as national wealth accentuates the positive effect of education on innovation and dampens the negative effect of age on it.

Limitations

The variable age used in our work is chronological age, which " is best conceived as a proxy for true mechanistic changes that influence cognition across time" (MacDonald et al., 2011). As innovation needs "strong analytical thinkers", individuals with high cognitive ability (De Visser et al., 2014), chronological age only approximates the true changes that occur over time in an individual's ability to innovate. We have also posited linear relationships in our conceptual model. However, curvilinear effects of age (Jones, 2010) and national income on innovation are more plausible. The variable innovation in our analysis is not an objective measure but is computed from entrepreneurs' self-reported responses to innovation-related questions. Finally, MLM has its own set of limitations that affect all studies that use this procedure including this research (González-Romá & Hernández, 2017). However, one specific limitation of MLM that affects studies with small datasets is not applicable in our case as both the number of groups (countries) and number of observations in each group are very large.

Contributions

We contribute to human capital theory by making a conceptual and empirical case against the use of work experience as a constituent of human capital. We explain the cause of counterintuitive and conflicting evidence in extant research on influence of human capital on innovation and suggest a path for its resolution. By using MLM, we contribute to the adoption of more robust methodological handling of GEM data. Using one of the largest available datasets, we carry out the first exploration of effect of entrepreneur age on innovation. We also theorize and test a novel set of moderating effects on innovation.

Implications for practice and future research directions

Given the disparities in educational provision between countries and the nexus among education, innovation, and economic prosperity, it is obvious from our findings that poorer countries should make investment in education their top priority. As demographic ageing has not yet set in, in these countries, this appears to be the straightest path to prosperity.

Though all developed countries perceive international students a key part of their intangible exports, not all allow them the opportunity to settle down. Adverse innovation implications of this policy are highlighted by this work. Its converse ramification for the less developed countries such as India and China, from where the largest number of international students originate, however, is that they are losing a potential source of innovation, their competitiveness, and future growth in this process, and they would gain by improving the quality of their educational delivery as well as by extending it.

We also hope that this work generates more conceptual debate and further research on composition of human capital. As this study is based on data that is predominantly of very small enterprises (Schøtt & Jensen, 2016), studies using multi-country data of larger organizations should provide a complementary perspective to this scrutiny.

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About the Authors

Vijay Vyas is Senior Lecturer in Entrepreneurship & Enterprise at the Faculty of Business & Law in University of Portsmouth in the United Kingdom. He holds a PhD from Edinburgh Napier University. He has been a Professor of Business Economics at the MS University in India and a visiting Professor in Entrepreneurship at Lancaster University in UK. He is the course director of MSc Innovation Management & Entrepreneurship at University of Portsmouth.

Renuka Vyas is PhD Research Scholar at Cardiff University in the United Kingdom. She holds a master's degree in Social Research with a distinction from Birkbeck College, University of London, and a master's in Economics from MS University of Baroda in India. She has been a Senior Lecturer in Economics at a Gujarat University college and a visiting Faculty in Entrepreneurship & Small Business Management at a Bhavnagar University Institute, both in India.

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Elon Musk and SpaceX: A Case Study of Entrepreneuring as Emancipation

Steven Muegge and Ewan Reid

> *"We are at a turning point in the history of space exploration and development. ... The established state-run industrial space sector is no longer the only game in town."*
>
> Gary Martin,
> Director of Partnerships, NASA Ames Research

Elon Musk and SpaceX are central to the profound change underway in the space industry, opening up the sector to entrepreneurship and innovation by non-traditional new entrants. We employ the emancipation perspective on entrepreneuring as a theoretical lens to describe, explain, and interpret the entrepreneuring activities of Musk to launch and grow SpaceX. Applying an event study approach that combines case methods and process theory methods on publicly-available sources, we develop six examples of seeking autonomy, seven examples of authoring, and four examples of making declarations– the three core elements of the emancipation perspective on entrepreneuring. Our work contributes to the theory and practice of innovation by adding to the corpus of descriptive case studies that examine entrepreneuring as an emancipatory process. Our results and our method will also also be of interest to space industry entrepreneurs, investors, analysts, managers, policy-makers, and officers at governmental space agencies.

Introduction

The article presents results from a case study of the entrepreneuring activities undertaken by Elon Musk between 2001 and 2015 to launch and grow Space Exploration Technologies Corporation (SpaceX, https://www.spacex.com/), a private commercial spaceflight venture. We employ the *emancipation perspective on entrepreneuring* (Rindova et al. 2009) as a theoretical lens to identify, describe, and interpret examples of seeking autonomy, authoring, and making declarations– the three core elements of entrepreneuring emancipation. Our work contributes to the theory and practice of innovation by adding to the corpus of descriptive case studies that examine entrepreneuring as an emancipatory process.

First proposed by Rindova et al. (2009) in the *Academy of Management Review*, Jennings et al. (2016, p. 81) describes the emancipation perspective as "groundbreaking," with "paradigm-shifting potential" for understanding entrepreneurship and innovation. While theory-building requires careful observation and accurate description (Christensen & Raynor, 2003) undertaken by engaged scholars (Van de Ven, 2007), the features of both description and explanation are strengths of case study research designs (Yin, 2014; Eisenhardt et al. 2016). Thus, we argue that a corpus of well-designed and rigorously-executed case studies that employ the emancipation perspective to examine high-impact technology innovations, could accelerate theory-building about technology entrepreneurship and innovation. Nonetheless, there remains a dearth of published case research on these topics (Jennings et al. 2016; Reid, 2018). This paper is the second in a series of case study publications addressing this gap by examining the activities of NewSpace entrepreneurs (Zubrin, 2013; Pekkanen, 2016; Martin, 2017). Our previous paper examined Sir Richard Branson and Virgin Galactic (https://www.virgingalactic.com/) (Muegge & Reid, 2018) and a forthcoming paper will examine Peter Diamandis and the XPRIZE Foundation (https://www.xprize.org/).

The article proceeds as follows. The first section reviews the relevant prior research perspectives on entrepreneuring emancipation. The second section describes the research method, and the third introduces the case of Elon Musk and SpaceX. The fourth, fifth, and sixth sections each present results about one of the three core elements of entrepreneuring: seeking autonomy, authoring, and making declarations, respectively. The seventh section discusses the results, and the eighth section concludes.

Entrepreneuring as Emancipation

Entrepreneuring refers to "efforts to bring about new economic, social, institutional, and cultural environments through the actions of an individual or group of individuals" (Rindova et al. 2009, p. 477). Entrepreneuring is thus about the creation of something new, not merely about change.

Emancipation refers to "the act of setting free from the power of another" (*Webster's Revised Unabridged Dictionary*, 1996). The focal point of inquiry is thus the "pursuit of freedom and autonomy relative to an existing status quo" (Rindova et al. 2009, p. 478).

The Rindova et al. (2009) *emancipation perspective of entrepreneuring* connects these two ideas, emphasizing verbs and actions rather than nouns and things. "We theorize that … three core elements are central to an emancipatory process" (p. 479):

- *Seeking autonomy* is the impetus for entrepreneuring– the perceived need of the entrepreneur to break free of or break up perceived constraints

- *Authoring* is defining new resource arrangements, relationships, and rules of engagement– taking ownership to change positions of power, to realize change-creating intent, and to preserve and enhance emancipatory potential

- *Making declarations* is about managing interpretations and expectations, mobilizing support, and generating change effects through discursive and rhetorical acts about intended change

The emancipation perspective emphasizes *change creation*: wealth creation may feature also, but it need not dominate the intended change. Rindova et al. (2009) write, "We believe that entrepreneurship research perhaps has become a bit too narrowly focused on wealth creation via new ventures" (p. 478) and "The implied opposition between emancipatory projects to create change and a 'hard-nosed business strategy' is a false one" (p. 483).

Method

Our research problem is the identification and description of the NewSpace entrepreneuring activities undertaken by Musk using the framework and constructs of the emancipation perspective on entrepreneuring. Our field setting is the space industry, which is currently in the midst of resurgence and profound change (Reid, 2018b, 2019; Davenport, 2018; Fernholz, 2018). Davenport (2016, p. 3) writes:

> *"Another space race is emerging, this time among a class of hugely wealthy entrepreneurs who have grown frustrated that space travel is in many ways still as difficult, and as expensive, as ever. Driven by ego, outsized ambition and opportunity, they are investing hundreds of millions of dollars of their own money in an attempt to open up space to the masses and push human space travel far past where governments have gone".*

Martin (2017), Director of Partnerships for the NASA Ames Research Center, writes: "The established state-run industrial space sector is no longer the only game in town" (p. 3).

Our research design is an *event study* (Van de Ven, 2007), combining *case methods* (Yin, 2014; Eisenhardt et al. 2016) with *process theory methods* (Poole et al. 2000) to operationalize the core constructs of the emancipation perspective. We focus on a single entrepreneur and their venture using publicly-available data sources. Our source for identifying events was a book-length biography, *Elon Musk: Tesla, SpaceX, and the Quest for a Fantastic Future* (Vance, 2015). Musk cooperated in the production of the book by providing interviews, documents, and access to other people, but did not review the book prior to publication or exert editorial control.

We employed NVivo qualitative data analysis (QDA) software, a set of coding rules, and a common framework for specifying events. Our analysis began with *incident coding* of the main source to identify and

tag relevant passages of text, followed by *event coding* of the incidents to identify and specify a set of emancipation events. We then enfolded additional evidence, context, and perspectives from other sources, including published interviews with Musk, press releases from the SpaceX website, and articles about Musk and SpaceX. Each event record in the QDA software preserved links to evidence in the source material.

Our use of publicly-available sources (rather than primary interviews) is similar to the approach of Rindova et al. (2009) in the seminal article about emancipation. First-hand accounts by the focal entrepreneur are triangulated with stories from others and with other publicly-available records.

Our outcome is a set of case results, presented in a narrative form, structured using the constructs of the emancipation perspective. We report seventeen emancipation events:

- Six *seeking autonomy* events as the impetus for entrepreneurship, describing Musk's perceived need to break free of or break up a perceived constraint

- Seven *authoring* events of Musk taking ownership by defining relationships, arrangements, and rules of engagement, and changing the positions of power

- Four *making declarations* events of Musk's discursive and rhetorical acts about change-creating intent

Elon Musk and Space Exploration Technologies Corporation (SpaceX)

According to the company website: "SpaceX designs, manufactures and launches advanced rockets and spacecraft. The company was founded in 2002 to revolutionize space technology, with the ultimate goal of enabling people to live on other planets."

Elon Musk was born in South Africa in 1971, moved to Canada in 1989 to attend Queen's University (Kingston, Ontario), then transferred to the University of Pennsylvania in 1991. After completing degrees in economics and physics, he moved to to Silicon Valley in 1995, where he launched and exited two technology startups. Vance (2015, p. 14) summarizes this period prior to SpaceX, as follows:

> *"Fresh out of college, he founded a company called Zip2—a primitive Google Maps meets Yelp. That first venture ended up a big, quick hit. Compaq bought Zip2 in 1999 for $307 million. Musk made $22 million from the deal and poured almost all of it into his next venture, a startup that would morph into PayPal. As the largest shareholder in PayPal, Musk became fantastically well-to-do when eBay acquired the company for $1.5 billion in 2002".*

Musk moved to Los Angeles in 2001. Regarding this move, Vance writes, "While Musk didn't know exactly what he wanted to do in space, he realized that just by being in Los Angeles he would be surrounded by the world's top aeronautics thinkers. They could help him refine any ideas, and there would be plenty of recruits to join his next venture" (p. 99). One of those people was Robert Zubrin, an aerospace engineer, advocate of human exploration of Mars, and co-founder of The Mars Society (https://www.marssociety.org). Like Musk, Zubrin was frustrated by the priorities and slow progress at NASA, saying, "America's human spaceflight program is now adrift" (2013, p. 24). He nevertheless noted "a bright spot on the horizon in the form of a wave of entrepreneurial activity, most particularly that of the SpaceX company" (p. 54).

Zubrin (2013, p. 56) describes some of his impressions of Musk:

> *"Unlike the other would-be space magnates, Musk did not simply throw an expendable chunk of his fortune into the game; he put the full force of his talent and passion into it. When I met Musk in 2001, he had a good grasp of scientific principles, but knew nothing about rocket engines. When I visited him at his first small factory in Los Angeles in 2005, he knew everything about rocket engines. By the time of my next visit a few years later, he had experienced two straight failures of his first launch vehicle, the Falcon 1, but was determined to push on despite the blows to his finances and reputation. It is this level of commitment that has made all the difference. None of the other billionaire-backed space startups have ever cleared the tower. SpaceX has delivered Cargo to the space station and will soon be sending people".*

By all close accounts (for example, Zubrin, 2013;

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Table 1. Timeline of Elon Musk and SpaceX (compilation of sources)

Year	Event
1971	Musk born in Pretoria, South Africa
1989	Musk moved to Canada to attend university (Queen's University in Ontario)
1991	Musk moved to the United States (transfer to the University of Pennsylvania)
1995	Musk moved to Silicon Valley and co-founded Zip2, a provider of websites for businesses
1999	Compaq acquired Zip2 for US$340M Musk founded X.com, a provider of online banking services
2000	X.com merged with Confinity to become PayPal
2002	PayPal acquired by eBay for US$1.5B
2001	Musk moved to Los Angeles to be close to the space industry
2002	Musk founded SpaceX with US$100M of own money
2006	First launch attempt: Falcon 1 rocket (failed) First contract: NASA Commercial Orbital Transport Services (COTS)
2008	First successful launch (fourth launch attempt): Falcon 1 rocket to low earth orbit (LEO) (expendable); also the first privately-funded liquid-propellant rocket to reach orbit First major operational contract: NASA Commercial Resupply Services (CRS) contract to resupply cargo to the International Space Station (ISS)
2010	Launch of a Falcon 9 rocket to LEO and a Dragon cargo spacecraft to orbit and back; SpaceX becomes the first private company to launch, orbit, and recover a spacecraft
2011	First development contract for manned spaceflight: an award from the NASA Commercial Crew Development (CCDev) program to develop an escape system for the Dragon 2 (Crew Dragon) capsule, a spacecraft for carrying astronauts
2012	Dragon cargo spacecraft (launched on a Falcon 9 rocket) docks with and delivers cargo to the ISS; SpaceX becomes the first private company to send a spacecraft to the ISS
2013	Grasshopper test rig demonstrated vertical take-off and landing, a significant milestone in the production of rapidly reusable launch systems
2014	First orbital rocket booster to return from space for ocean landing (Falcon 9; expendable)
2015	First orbital rocket booster to return from space and land on land (Falcon 9; expendable)
2016	First successful drone ship landing of orbital rocket boosters (Falcon 9; recovered)
2017	Musk publishes the SpaceX Mars architecture and detailed vision of humans as a multi-planetary species (Musk, 2017) First commercial re-flight of a previously-recovered spacecraft (Falcon 9 rocket)
2018	First launch of Falcon Heavy orbital heavy-lift launch vehicle; two of the three recoverable boosters were successfully recovered (one was not); payload was a Tesla Roadster with real-time cameras and "Starman" astronaut driver, launched towards Mars; SpaceX becomes the first private company to launch an object into orbit around the sun
2019	First launch of Crew Dragon capsule (rated for human spaceflight) to dock with the ISS; returned from space for ocean landing (expendable)
2019	Planned first launch of crewed Crew Dragon capsule carrying astronauts to the ISS

Diamandis & Kotler 2015; Vance, 2017), Musk's ultimate ambition, even before founding SpaceX in 2002, was sustainable human settlement on Mars, thus making humans a multi-planetary species (Musk, 2017).

Table 1 reports a timeline of Musk's early entrepreneurial activities, significant milestones for SpaceX, and stated future goals. Our emphasis here is exclusively SpaceX. Musk's other business and not-for-profit ventures subsequent to founding SpaceX–including Tesla (2003), SolarCity (2006), Hyperloop (2012), OpenAI (2015), Neuralink (2016), and The Boring Company (2016), are therefore not part of the article's scope. The following three sections each introduce one of three core elements in the emancipation perspective. They report examples identified from the main source (Vance, 2015), and supported with further details from additional sources. Page numbers refer to Vance (2015) unless otherwise noted. Because our main source for identifying emancipation events was published in 2015, all of the examples that follow began prior to 2015.

First Core Element: Seeking Autonomy

Seeking autonomy is the entrepreneurial impetus of the emancipation perspective– the perceived need of the entrepreneur to break free of or break up a perceived constraint in the environment (Rindova at al. 2009). For

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Schumpeter (1942), creative destruction was a *means* of entrepreneurship, but in the emancipation perspective it is also a *goal*: an entrepreneur seeks escape by overcoming or removing perceived constraints that "can be of an intellectual, psychological, economic, social, institutional, or cultural nature" (Rindova et al. 2009, p. 479).

A first example of seeking autonomy was Musk's perceived need to break free of the constraint that *space had become boring*. People "had grown cynical about anything novel happening in space again" (p. 103). "Musk would inspire people to think about exploring space again by making it cheaper" (p. 108). "He wanted to inspire the masses and reinvigorate their passion for science, conquest, and the promise of technology" (p. 101). Musk (2017, p. 46) writes: "I want to make Mars seem possible—make it seem as though it is something that we can do in our lifetime. There really is a way that anyone could go if they wanted to."

A second example was Musk's perceived need to *do something that matters*, breaking free of the constraint that the Internet runs on advertising and low-impact problems, and that top talent is too-often wasted on selling more ads. Musk states: "There are probably too many smart people pursuing Internet stuff, finance, and law" (p. 9). "Where Mark Zuckerberg wants to help you share baby photos, Musk wants to… well… save the human race from self-imposed or accidental annihilation" (p. 17). "[Musk's] empathy is unique. He seems to feel for the human species as a whole without always wanting to consider the wants and needs of individuals" (p. 363).

A third example was Musk's perceived need to be CEO *in control of his own company*. Musk "wanted to be CEO" (p. 67), but "at both Zip2 and PayPal, the companies' boards came to the conclusion that Musk was not yet CEO material" (p. 91). Both companies "had been ripped away from Musk and given to someone else to run" (p. 97). Musk founded SpaceX with US$100M of his own money from the acquisition of PayPal by eBay in 2002. Launching, growing, and exiting two previous companies provided credibility, and investing his own money provided autonomy. "With such a massive up-front investment, no one would be able to wrestle control of SpaceX away from Musk as they had done at Zip2 and PayPal" (p. 116). In a 2013 email to staff, Musk wrote: "Creating the technology needed to establish life on Mars is and always has been the fundamental goal of SpaceX. If being a public company diminishes that likelihood, then we should not do so until Mars is secure" (p. 260).

A fourth example was breaking free of *dependency on Russian launch vehicles*. "The Russians were the only ones with rockets that could possibly fit within Musk's budget" (p. 103). Instead of contracting out, SpaceX built the Falcon rocket for small payload missions: "Musk would inspire people … by making it cheaper to explore space" (p. 108).

A fifth example, one that was central to Musk's identity and ultimate ambitions, was breaking free of the obvious constraint that there were *no humans on Mars*. Musk was frustrated that humans had no way to travel to Mars, and even more so, that there were no credible projects to get humans to Mars at any point in the future. Musk states: "At first I thought NASA just had a badly designed website. Why else couldn't you find this critical piece of information that would obviously be the first thing you'd want to know when you go to NASA.gov? But, it turned out, NASA had no plans for Mars. In fact, they had a crazy policy that didn't even let them talk about sending humans to Mars" (Diamandis & Kotler, 2015, p. 118). Musk also dreamed bigger, not only to travel to Mars, but to live there: "The thing that's important in the long run is establishing a self-sustaining base on Mars. In order for that to work– in order to have a self-sustaining city on Mars– there would need to be millions of tons of equipment and probably millions of people" (p. 332).

A sixth example was breaking up the entrenched notion that *space is special*—not like other industries– implying a set of constraints that prohibited practices that were effective elsewhere. Anything designed and built for space is expensive and takes a long time (p. 114), and rockets and capsules were used only once. "So long as we continue to throw away rockets and spacecraft, we will never have true access to space" (p. 257). Musk therefore demanded reusable rockets, reusable capsules, and massive cost reduction:

> • SpaceX rockets "push their payload to space and then return to Earth and land with supreme accuracy on a pad floating at sea or even their original launchpad" (p. 217).
>
> • "SpaceX proved that the Falcon 9 could carry the Dragon capsule into space and that the capsule could be recovered" … "The Dragon 2 will … [use] SuperDraco engines and thrusters to come to a gentle stop on the ground. No more landings at sea. No more throwing spaceships away" (p. 254,

257).

• "Musk's goal is to use manufacturing breakthroughs and launchpad advances to create a drastic drop in the cost of getting things to space" (p. 217).

Consistent with the emancipation perspective on entrepreneuring, seeking autonomy was an impetus for action. Musk was driven to action by at least six perceived constraints: (1) space had become boring, (2) profitable tech companies too often address low-impact problems, (3) founder-entrepreneurs give up control of successful companies, (4) launches required Russian launch vehicles, (5) there were no humans on Mars, and no credible plans to send humans there, and (6) shared belief that practices driving massive cost-reductions in other industries would not work in space. He sought escape from these constraints by launching SpaceX– to inspire, to do something that matters, to be in control, to demonstrate that change is possible, and ultimately, to put humans on Mars.

Second Core Element: Authoring

Authoring refers to taking ownership by defining relationships, arrangements, and rules of engagement, and changing the positions of power. "Authoring does not refer to an outright rejection of all established norms and forms of authority but, rather, designing arrangements that support the change-creating intent of the entrepreneuring individual" (Rindova et al. 2009, p. 484). The authoring entrepreneur positions an entrepreneurial project in a system of resource relationships with resource holders. This contrasts with the opportunity recognition and creation themes prevalent in entrepreneurship research.

A first example of authoring was Musk *joining the network*. Prior to 2001, Musk was an outsider to the space industry. Musk's 2001 move from Silicon Valley to Los Angeles gave him access to the space industry (p. 97). Musk joined social networks: he donated to the Mars Society and Mars research (p. 100), joined the Mars Society board of directors, announced founding the Life to Mars Foundation (p. 102), discussed investing $20M to $30M in a Mars project (p. 103), and built connections with ambitious engineers (p. 111).

A second example was Musk's (unsuccessful) attempt to *buy Russian missiles*. Launches required specialized launch vehicles such as Russian Soyuz rockets. In 2002, "Musk intended to buy a refurbished intercontinental ballistic missile, or ICBM, from the Russians and use that as his launch vehicle" (p. 104). Musk met with Russians twice in Moscow and once in California. He was willing to pay $20M for three ICBMs, but did not reach a deal (pp. 106-107). This was a novel approach that had not previously been attempted.

A third example was organizing SpaceX as a *Silicon Valley space company*. "Musk felt that the space industry had not really evolved in about fifty years. The aerospace companies had little competition and tended to make supremely expensive products that achieved maximum performance. They were building a Ferrari for every launch" (p. 114). When he founded SpaceX in 2002 with US$100M of his own money, he brought with him a Silicon Valley way of thinking. Vance describes how "[Musk] had taken much of the Silicon Valley ethic behind moving quickly and running organizations free of bureaucratic hierarchies and applied it to improving big, fantastic machines and chasing things that had the potential to be the real breakthroughs we'd been missing" (p. 14). Musk set "insanely ambitious timelines" (p. 114), used open-concept offices where scientists and engineers worked alongside welders and machinists (p 113), hired young overachievers fresh from college for rank-and-file engineers and poached top engineers from Boeing, Lockheed Martin, and Orbital Sciences (p. 120), contracted with suppliers outside of the aerospace sector (p. 132), and "never relented in asking his employees to do more and be better" (p. 131). "The only way to keep up", explains Vance, "was to do what SpaceX had promised from the beginning: operate in the spirit of a Silicon Valley start-up" (p. 130).

A fourth example was utilizing *unconventional launch facilities*. Launch tests traditionally happened at air force bases, imposing high costs and long wait times. Musk instead procured a former U.S. military missile test site on the Kwajalein Island (Kwaj) between Guam and Hawaii in the Marshall Islands, and adapted it to his needs (p. 135).

A fifth example was creating the *SpaceX system* as an end-to-end *modular engineering platform* (Baldwin & Clark, 2000; Muegge, 2013; Gawer & Cusumano, 2014) of launch vehicles, capsules, and engines that were all designed, manufactured, assembled, and tested at SpaceX facilities. Components included the Falcon 1, Falcon 5, Falcon 9, Falcon Heavy, and ITS Launch Vehicle, the Dragon and Dragon 2 capsules, and the Merlin, Kestrel, Draco, and SuperDraco engines. (These are the component names used by Vance for the components of the SpaceX system. As of 2019, several

components have been renamed, new components have been added, and some components are no longer used. However, the principle of a modular platform architecture remains deeply entrenched). SpaceX sourced key capabilities in-house and "increased its internal welding capabilities so that it could make the fuel tanks in [a SpaceX facility] and ditch Spincraft [a suppler]" (p. 132). "[Musk] doesn't want to handle a few launches per year or to rely on government contracts for survival. Musk's goal is to use manufacturing breakthroughs and launchpad advances to create a drastic drop in the cost of getting things to space" (p. 217). Musk's ambitions about Mars shaped even the earliest design decisions about system architecture and components intended for low Earth orbit: "NASA researchers studying the Dragon design have noticed several features of the capsule that appear to have been purpose built from the get-go to accommodate a landing on Mars ... It could be feasible for NASA to fund a mission to Mars in which a Dragon capsule picks up samples and returns them to Earth" (p. 235).

A sixth example was *commercial contracts*. Prior to SpaceX, NASA contracted only with traditional aerospace and military suppliers. In 2006, SpaceX contracted with NASA and the U.S. Military to develop technology, and in 2008, to operate missions. In 2012, a Dragon capsule became the first private spacecraft to dock with the International Space Station (Chang, 2012). In 2019, a Crew Dragon capsule became the first private spacecraft rated for human transportation to dock with the ISS (O'Callaghan, 2019); it returned successfully to earth a few days later for an ocean landing (Wall, 2019). SpaceX expects to transport a human crew to the ISS later in 2019.

A seventh example was a viable plan for *humans as an interplanetary species*. If a catastrophic event were to render Earth unfit for human life, neither human civilization nor the human species would survive. "Musk's ultimate goal" according to Vance, is "turning humans into an interplanetary species. This may sound silly to some, but there can be no doubt that this is Musk's raison d'etre" (p. 331). Musk (2017, p. 46) writes:

> *"Why go anywhere? I think there are really two fundamental paths. History [is] going to bifurcate along two directions. One path is we stay on Earth forever, and then there will be some eventual extinction event. I do not have an immediate doomsday prophecy, but eventually, history suggests, there will be some doomsday event. The alternative is to become a space-bearing civilization and a multi-planetary species, which I hope you would agree is the right way to go."*

Consistent with the emancipation perspective on entrepreneuring, Musk took ownership by defining new arrangements in place of the established status quo of the traditional space industry. He first became embedded in the social communities of people in the space industry through action and investment, then sought to privately obtain unconventional launch vehicles, then launched SpaceX with his own personal funds as a Silicon Valley space company, utilizing unconventional launch facilities, developing a modular platform of re-usable components, and securing commercial contracts, with an ultimate goal of making humans an interplanetary species. Musk's SpaceX status quo operated under different rules and arrangements than the traditional space industry status quo that it displaced, and preserved emancipatory potential for continued change.

Third Core Element: Making Declarations

Making declarations refers to "unambiguous discursive and rhetorical acts regarding the actor's intentions to create change" … "[d]eclarations are intended for specific audiences and are bound by customs of rhetoric, speaking, and listening" (Rindova et al. 2009, p. 485, 486). Unlike legitimation activities that disguise differences, entrepreneuring may involve exposing contradictions and differences to generate stakeholder support for an intended change in the status quo. Contestations from others may be an inevitable consequence of declarations: "The process of declaration and contestation ... is also one of meaning and rhetoric and ultimately of altering societal beliefs about the very nature of things" (p. 486). The entrepreneur making declarations positions an entrepreneurial project within the web of meaning within which stakeholders interpret the value of products and activities.

A first example of making declarations was Musk's *commitment and persistence to building a SpaceX launch vehicle*. After failing to secure a Russian missile in 2002, Musk declared: "I think we can build this rocket ourselves" (p. 107). The SpaceX website boldly stated: "SpaceX is privately developing the entire Falcon rocket from the ground up, including both engines, the turbo-pump, the cryogenic tank structure and the guidance system" (p. 118). Initial reactions were tepid: "As word travelled around the space community about Musk's plans, there was a collective ho-hum [from people who had seen this situation before]... The techies usually

ended up spending the rich guy's money for two years, and then the rich guy gets bored and shuts the thing down" (p. 108). Musk nonetheless persisted, spending his own money.

A second example was Musk's *commitment to persevere*. Musk vowed to continue despite three failed test launches and severe time and cost overruns, declaring "I will spend my last dollar on these companies. If we have to move into Justine's parents' basement, we'll do it" (pp. 198-199). He made confident statements to employees and the public after each setback. "It took six years– about four and a half more than Musk had once planned– and five hundred people to make this miracle of modern science and business happen" (p. 203). The fourth test launch finally succeeded in 2008, when "SpaceX simply did not have enough money to try a fifth flight" (p. 200). "When the launch was successful, everyone burst into tears" (p. 203). Musk told Diamandis & Kotler (2015, p. 122): "Even if the probability of success is low, if the objective is really important, it's worth doing."

A third example was making declarations about a *new paradigm in the space industry*. Musk declared that SpaceX would do things differently, and insisted that massive cost reduction was both necessary and possible. Tom Mueller explained: "People thought we were crazy. At TRW, I had an army of people and government funding. Now we were going to make a low-cost rocket from scratch with a small team" (p. 116). "The whole situation was ludicrous. A start-up rocket company had ended up in the middle of nowhere trying to pull off one of the most difficult feats known to man" (p. 137). Musk persevered and succeeded. By 2015, "SpaceX spent $2.5 billion to get four Dragon capsules to the ISS, nine flights with the Falcon 9, and five flights with the Falcon 1. It's a price-per-launch total that the rest of the players in the industry cannot comprehend let alone aspire to" (p. 247). Musk (2017) detailed the SpaceX Mars vision of humans as a multi-planetary species:

> *"As we show that this is possible and that this dream is real–it is not just a dream, it is something that can be made real–the support will snowball over time."*

A fourth example was making declarations that SpaceX would *remain privately held* to pursue its ambitious goals of making humans an interplanetary species. Musk wrote a 2013 letter to SpaceX employees about the timing of going public (p. 260), and made consistent statements about staying private: "For those who are under the impression that they are so clever that they can outsmart public market investors and would sell SpaceX stock at the 'right time,' let me relieve you of any such notion." Zubrin (2013) writes: "At SpaceX, initially all–and still a significant fraction today–of the funds spent have been Musk's. In short, SpaceX spends money as like it is its own–because much of it is" (pp. 57-58). Musk (2017, p. 57) writes:

> *"The main reason I am personally accumulating assets is in order to fund this. I really do not have any other motivation for personally accumulating assets except to be able to make the biggest contribution I can to making life multi-planetary."*

Consistent with the emancipation perspective on entrepreneuring, Musk made unambiguous discursive and rhetorical acts regarding intentions to make change. Musk's declarations were about building a launch vehicle (and later the SpaceX system) with private funds, persevering despite set-backs, doing things differently, and remaining privately-held. Musk's declarations shaped the interpretations of stakeholders about the value and meaning of SpaceX activities and intent for change.

Discussion

Our research problem was the identification and description of the NewSpace entrepreneuring activities of Elon Musk using the framework and constructs of the emancipation perspective on entrepreneuring. Our solution was a set of seventeen examples of entrepreneuring as emancipation: six examples of Musk *seeking autonomy* as an impetus for entrepreneurship, seven examples of *authoring* to enact change, and four examples of *making declarations* about change-creating intent. Admittedly, these examples may provide an incomplete and partial view of Musk and SpaceX. Nonetheless, we argue that our work here is insightful for theory and practice. In the paragraphs that follow, we discuss and position (1) the results of this case, (2) the implications about the emancipation perspective, and (3) the broader implications about understanding entrepreneurship and innovation.

Our case results, interpreted through the lens of the emancipation perspective on entrepreneuring, portray Musk as driven to action by seeking escape from perceived constraints: space had become boring, tech companies addressed low-impact problems, successful founder-entrepreneurs lost control of their companies, launches required Russian launch vehicles, humans

lived only on earth, and practices that had driven massive cost-reduction in other industries were not used in space. SpaceX was the means for liberation: to inspire, to do things that matter, to maintain control, to show change is possible, and to make humans into a multi-planetary species. Musk authored new arrangements in place of the industry status quo, in particular founding SpaceX with personal funds as a Silicon Valley space company, with unconventional facilities, a modular platform of re-usable components, and commercial contracts to develop technology and provide services. Musk made declarations to shape interpretations of stakeholders about the value and meaning of SpaceX activities and intent for change– about building a launch vehicle and the SpaceX system, persevering despite set-backs, doing things differently, and remaining privately-held.

Musk may be an atypical entrepreneur in both attributes and circumstances. In a new epilogue written for the paperback edition, Vance (2017, p. 374) writes that, "Musk does not operate like your typical CEO. He's charging after a personal calling– one that's intertwined with his soul and injected into the deepest parts of his mind." Furthermore, Musk began SpaceX with a personal fortune, a munificent resource environment that is unavailable to most entrepreneurs. We purposely selected Musk and SpaceX as an extreme case in pursuit of fresh insights, following the research design advice of March et al. (1991), Christensen & Raynor (2003), Van de Ven (2007), Yin (2014), and Eisenhardt et al. (2016). Nonetheless, we found that the emancipation perspective was valid here also in an extreme case for identifying, describing, and explaining Musk's entrepreneuring activities. This suggests that the emancipation perspective may be applicable to entrepreneurship with broad *scope conditions* (Suddaby, 2010) that include the most extreme outlier cases. Jennings et al. (2016, p. 99) had previously observed that most empirical work utilizing the emancipation perspective has been conducted in developing economies or with marginalized populations. Our results therefore lead us to call also for empirical investigation of entrepreneuring as emancipation in the world's most-developed economies, most-advanced technologies, and most-advantaged populations. Likewise, our results support the Rindova et al. (2009) assertion that "implied opposition between emancipatory projects to create change and a 'hard-nosed business strategy' is a false one" (p. 483). SpaceX is *both* a profitable venture inspired by dreams *and* a social mission with profit potential. Musk *simultaneously* pursues a bold societal goal *while* building a successful company. The emancipation perspective thus accommodates social outcomes and wealth creation within the same framework, thereby calling into question the common practice of treating social entrepreneurship as somehow different from "regular" entrepreneurship.

Some of Musk's entrepreneuring activities appear anomalous from a strict wealth-creation perspective. However, these same activities appear coherent and logically consistent when interpreted as emancipatory change creation to escape from perceived constraints. Other theoretical perspectives on entrepreneurship may also offer coherent explanations for some of Musk's activities — for example, *entrepreneurial hubris* (Hayward et al. 2006) could perhaps account for the relentless perseverance in 2008 for a fourth launch attempt despite three failures and dwindling resources, *entrepreneurial effectuation* (Saravathy, 2001) could account for organizing SpaceX as a Silicon Valley company in an industry that organized in unfamiliar ways, and *entrepreneurial bricolage* (Baker & Nelson, 2005) could account for both the attempt to procure Russian missiles and the use of unconventional launch facilities. A rigorous consideration of hubris, effectuation, bricolage, and other perspectives is beyond the scope of the current article. However, each of these alternative perspectives appears likely to inform only a subset of the seventeen examples of entrepreneuring as emancipation identified here, and each perspective seems incompatible with or unhelpful for explaining other examples. There are at least two broader implications for scholarship. First, researchers of entrepreneurship and innovation phenomena should continue to adopt multiple theoretical perspectives, a tactic advocated by Christensen & Raynor (2003), Van de Ven (2007), Yin (2014), and others for methodologically rigorous and high-impact management research. Second, the emancipation perspective can provide an organizing framework that accommodates wealth-creation, hubris, bricolage, effectuation, and other perspectives on entrepreneurship and innovation as partial and complementary explanations of the motivations and processes for some entrepreneuring activities. We agree with Rindova et al. (2009, p. 478) that "research that considers both more closely and more broadly the entrepreneurial dreams and efforts to create change in the world may bring us to a fuller, more comprehensive understanding of the processes of discovery, change, value creation, and ultimately wealth creation" — especially for technology entrepreneurs.

Limitations of this research include the single-case research design, use of a single narrative source for identifying emancipatory events (Vance, 2015), and exclusive reliance on text sources (i.e., no primary interviews or direct observation). We attempted to address the threats to validity and reliability resulting from these limitations by employing the best practices recommended in the case method literature (Yin, 2014; Eisenhardt et al. 2016), and developing additional cases about other entrepreneurs (Reid, 2018a; Muegge & Reid, 2018) for cross-case comparisons (Eisenhardt, 1989; Yin, 2014). Nonetheless, coding additional sources about Musk and SpaceX could reveal more examples. Future research should develop more cases of entrepreneurs in the space industry to more fully describe this sector and to enable cross-case comparison within the industry, develop more cases in other sectors to enable cross-case comparison between industries, and examine more variables to understand how emancipation relates to other management constructs, and to high-impact research questions about entrepreneurship, innovation, competitive advantage, and benefits to stakeholders.

Conclusion

This article has employed the emancipation perspective on entrepreneuring (Rindova et al. 2009) to examine the case of Elon Musk and SpaceX, a "Silicon Valley space company" at the centre of profound change underway in an industry that was once the exclusive domain of government, military contractors, and incumbent aerospace companies. Our work adds to the corpus of descriptive case studies that examine entrepreneuring as an emancipatory process, and demonstrates the application of emancipation as a unifying perspective on entrepreneurship and innovation anchored around change creation.

As an entrepreneur, Musk is an outlier in multiple respects. Nonetheless, we showed that the emancipation perspective accommodated our case results within its framework: *seeking autonomy* as an impetus for entrepreneurship, *authoring* to enact change, and *making declarations* about change-creating intent. We also demonstrated the capability for emancipation to enfold other perspectives from the entrepreneurship literature, such as bricolage and effectuation as partial explanations for authoring events, and both wealth-creation and liberation from established social order as possible forms of change-creating intent. We agree with the Jennings et al. (2016) assertion that the emancipation perspective has much potential for new knowledge production and fresh insights in a wide range of management contexts. We argue in conclusion that our results support broad scope conditions for the emancipation perspective that includes the most-advanced technologies, most-developed economies, and most-advantaged entrepreneurs, as well as developing economies and individuals most in need of liberation.

Further Reading

A previous version of this article was presented at the *ISPIM Connects Ottawa* conference (April 7-10, Ottawa, Canada), and published in the conference proceedings (Muegge & Reid, 2019).

This is the second in a series of case studies examining the activities of NewSpace entrepreneurs using the emancipation perspective on entrepreneuring. Results from our case study of Sir Richard Branson and Virgin Galactic were previously presented at the *2018 Portland International Conference on Management of Engineering and Technology* (PICMET '18, August 19-23, Honolulu, Hawaii, USA), and published in the conference proceedings (Muegge & Reid, 2018).

Ewan Reid's Master of Applied Science Thesis (Reid, 2018a) is available online through the Carleton University open access repository (CURVE): *https://curve.carleton.ca*

Elon Musk and SpaceX

Steven Muegge and Ewan Reid

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About the Authors

Steven Muegge is an Associate Professor of Entrepreneurship at Carleton University in Ottawa, Canada. Dr. Muegge leads an active research program in technology entrepreneurship within the Technology Innovation Management (TIM) program. His research, teaching, and community service interests include platforms, communities, and business ecosystems, and the business models of technology entrepreneurs, especially in early-stage product-market spaces. Dr. Muegge holds a Bachelor of Engineering degree in Engineering Physics from McMaster University, a Master of Engineering degree in Telecommunications Technology Management from Carleton University, and a Ph.D. in Management from Carleton University.

Ewan Reid is President and CEO of Mission Control Space Services, a space exploration and robotics company with a focus on mission operations, onboard autonomy, and artificial intelligence. Prior to founding Mission Control, Ewan worked at a major Canadian space company as a systems designer and project manager. He has been a subsystem design lead on three rover prototypes for the Canadian Space Agency, a systems and electrical designer and operations engineer on the Space Shuttle Program, and a mission controller for ten Space Shuttle missions at NASA. Ewan has degrees in Electrical Engineering and Economics from Queen's University and a Master's degree in Technology Innovation Management from Carleton University.

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Escaping the 'Faster Horses' Trap: Bridging Strategic Foresight and Design-Based Innovation

Adam Gordon, Rene Rohrbeck, and Jan Schwarz

> *"If I had asked **them** what they wanted, they would have said faster horses!"*
>
> Attributed to Henry Ford

Design thinking is inherently and invariably oriented towards the future in that all design is for products, services or events that will exist in the future, and be used by people in the future. This creates an overlap between the domains of design thinking and strategic foresight. A small but significant literature has grown up in the strategic foresight field as to how design thinking may be used to improve its processes. This paper considers the other side of the relationship: how methods from the strategic foresight field may advance design thinking, improving insight into the needs and preferences of users of tomorrow, including how contextual change may suddenly and fundamentally reshape these. A side-by-side comparison of representative models from each field is presented, and it is shown how these may be assembled together to create foresight-informed design-based innovation.

Introduction

Design thinking is an innovation approach based on the processes by which creative designers think and work (Brown, 2008; Rowe, 1987). Presenting a codified framework and repeatable methodology for innovation, at a time when innovation is highly prized in business activity and competitive strategy, design thinking has gained rapid adoption, particularly in innovation practice over the last decade. As design thinking has taken hold, the process has been expanded from innovating products and services to improving management thinking and decision-making processes, "bringing designers' principles, approaches, methods, and tools to problem solving" (Brown, 2009).

Strategic foresight as a field strives for non-predictive understanding of plausible future states that may come to be in a market, sector or industry, in order to improve present strategic decisions. As design thinking has emerged, it has stimulated thinking in the foresight field as to whether, and if so, how design thinking may be used to improve strategic foresight (Kelliher & Byrne, 2015). Chermack and Coons (2015) refer to a "fertile soil" in the integration of design thinking and strategic foresight. The overlap between these fields was the subject of a special issue of the journal *Futures* (Vol. 74; 2015), with particular attention to connections between design thinking and scenario planning. It has also been a theme of a recent Design Management Academy conference, Hong Kong, 2017 (Buhring, et al., 2017).

Such publications and activities deal with why and how design thinking improves strategic foresight. The equivalent, opposite benefit has not been considered, which is our purpose here. We address the benefits of strategic foresight-informed design thinking, identifying some of the enhancements it offers to standard design thinking, particularly in facing vulnerability to sudden industry change. This is the "why" question we pose and answer. Further, we consider the "how question": how strategic foresight may be incorporated into design thinking, in a way that maintains the integrity of the design thinking method. In a side-by-side comparison of representative models from each field, we show how its benefits can be adopted and integrated. Our goal is not to amalgamate design thinking and strategic foresight. These are different methodologies, set up to

resolve different types of problems and achieve different goals, and should remain so. Our purpose is to show how and why strategic foresight is important to design thinking and how its benefits can judiciously be inserted into the design thinking methodology.

In either version of the design thinking strategic-foresight association, the key nexus point in their overlap is the self-evident axiom that every product of design thinking will, by definition, be used in the future (Evans, 2014; Selin et al., 2015). In this, design thinking processes can sharpen future-expectations, particularly in anticipating consumer reaction to new technologies and products; equally it suggests that a design thinking innovation format that consciously and robustly account for future changes within its process, will be more successful than design thinking that does not.

In building an understanding of the role of foresight in design thinking, we refer to commonly accepted practice models of design thinking. In particular, these are the Stanford D-School's (the Hasso Plattner Institute of Design) 5-step process (dchool.stanford.edu); the European Hasso-Plattner-Institut's 6-step process (hpi-academy.de); the British Design Council's 'Double Diamond' (designcouncil.org.uk); and the 3i's model based on Inspiration, Ideation, Implementation associated with Ideo (Brown, 2008). Across these various sources, it is apparent that none of these accepted design thinking models includes a "step" that directly addresses foresight, or attempts to create a point of view of contextual future-oriented change. Studying the activities that characterize the steps of design thinking as cited above, including the early phases commonly referred to as "discovery" or "inspiration," or user "observation" and "empathy," leads us to conclude that foresight is at best only very tangentially considered in the process, if at all. User observation may or may not lead, for example, to a trend-over-time insight, but the primary focus remains capturing a deep understanding of users in the present time.

Nevertheless, it is apparent that there exists among design thinkers a general awareness that sectors and industries are subject to constant change and often rapid and surprising shifts, so it is not surprising that we find evidence of interest in strategic foresight in the design thinking literature. In the context of design thinking, Kjaersgaard et al. (2016) comment that one needs to discuss "futures". Pollastri et al. (2016) report on the use of scenarios as a method to foster visual conversations on research future design applications (see also Shumack, 2014). While Lawson (2005) has said imagining design solutions means to project a divergent context from what exists, so any design endeavor embraces the assertion of an alternative future. Observation of (the limitations of) embedded mental models, a core foresight process, can be observed in Christensen & Schunn (2009). Relevance of foresight for design thinkers is supported by design thinking that goes beyond the remit of product and or service innovation, into an approach that "can help strategic and systems innovators make the new worlds they've imagined come to pass" (Brown & Martin, 2015). At this level, where design thinking is involved with organization strategy renewal, Sato et al. (2010) have described how Hewlett-Packard "exploited design thinking to support change, envision the future, and enhance portfolio planning". Beyond even this, design thinking is sometimes put at the service of transformative visions for social innovation or long-term change. For example, Scupelli et al. (2016) report on the integration of futures thinking with design thinking in the context of university education.

In these various conceptualizations, we find design thinking recognizing the need to take stock of future uncertainty and to create foresight intelligence as part of enacting successful designs. However, while design thinkers may apprehend some benefits from structured future-oriented thinking, there is currently no framework for design processes that enables this. It is into this circumstance that we seek to make an intervention: we aim to clarify how strategic foresight approaches may augment design thinking, and to build a new model without disturbing the fabric or underlying philosophy of design thinking methods.

This paper proceeds as follows: in Section 2, we summarize the rationale and processes of design thinking, and address the core vulnerability ("faster horses problem") that pertains. In Section 3, we outline key principles and practices of strategic foresight, and detail where and how these augment design thinking perspectives. In Section 4, we build a model for the part-integration of strategic foresight into design thinking, followed by discussion and conclusions.

Design Thinking: The Status Quo

We have referred above to the foundational and most commonly accepted process models for design thinking. Beyond this we also note that while there is

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variation in the specifics, there is considerable agreement across the field as to the key steps as well as the rationale behind them. Foundational codifications in such texts as Beckman and Barry (2007), Brown (2008), Martin (2009), or Liedtka & Ogilvie (2011), rest on an end-user-centered "build to learn" process, with phases of inspiration, ideation, and implementation. Seidel & Fixson (2013) observe three elements: need-finding, which encompasses the definition of a problem or opportunity through observation; brainstorming, which is a formal framework for ideation; and prototyping, which involves building models to facilitate the development and selection of concepts. For Liedtka (2015), rigorous experimentation is used to sift through the many possible solutions that are produced by rapid ideation in the design process.

In view of the essential similarities of these models above, and in the interest of simplicity, we choose to use one model from among those cited in section 1, which covers the mainstream of design thinking methods. It also provides a template against which to address the need for and potential role of strategic foresight. This analysis may equally be worked out with another of the design-oriented models.

The Stanford D-School model, chosen here for its widespread recognition, puts the elements and

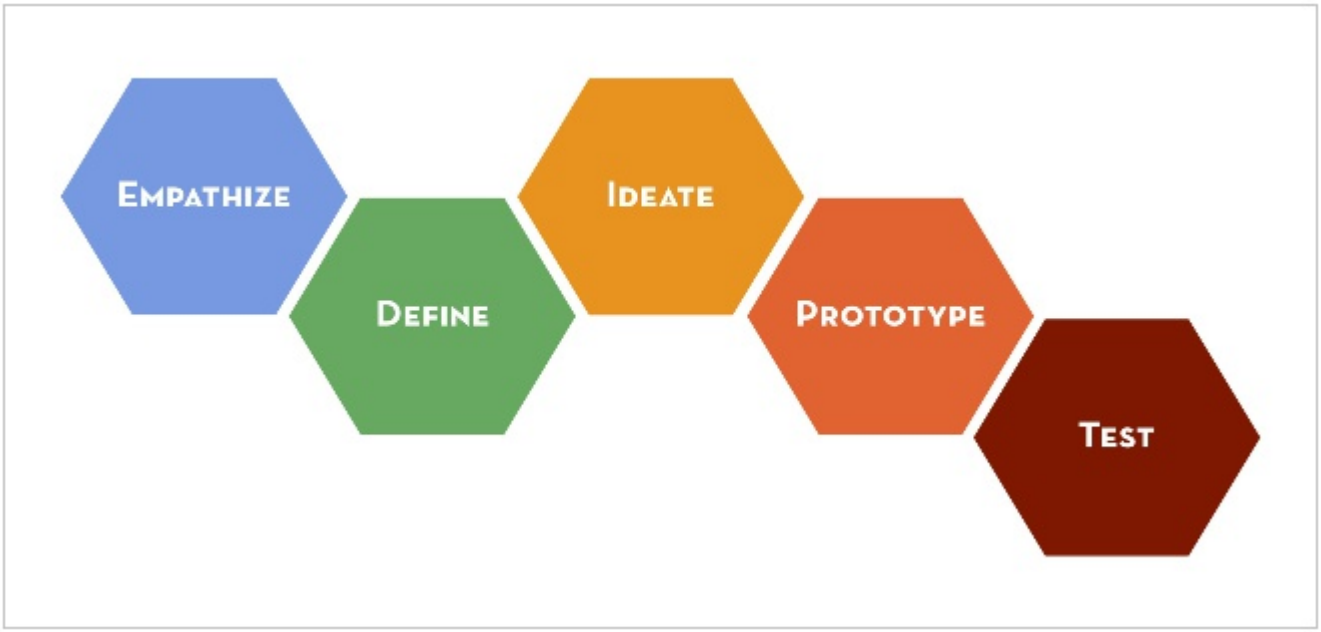

Figure 1: Steps in the Design Thinking Process. dschool.stanford.edu/resources

Empathy: a process of observing users' preferences and discovering their needs, both overt and latent. This may also be described as 'need-finding,' 'deep listening,' or undertaking a learning journey to tune into users' behaviors, preferences, and needs.

Define: this phase builds on an awareness of peoples' needs and preferences, towards developing insights into what their core problem is that seeks a solution, or what opportunity is to be pursued.

Ideate: here the design thinker or team develops ideas for solutions, according to a process whereby judgment is suspended, and both quantity and quality of options is encouraged.

Prototype: this involves narrowing the ideation results toward a rough, early solution to a specific problem, which can be rendered as a sketch or model or early working solution. Prototypes convey an idea and solution quickly, and allow it to be appraised and improved.

Test: this forms part of an iterative process of learning what works and what doesn't, modifying the basic prototype until it is ready to move into production and enterprise forms, and all of the ensuing scale-up.

In view of the essential similarities of these models above, and in the interest of simplicity, we choose to use one model from among those cited in section 1, which covers the mainstream of design thinking methods. It

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The 'Faster Horses' Problem

Taking the model above, particularly the "empathize" and "define" steps, strategic foresight would term what design thinking does here (particularly in its observatory, outward-bound character) as a "learning journey" (Milojevic & Inayatullah, 2015). This may be part of a broader externally-oriented "horizon scanning" (Konnola, et. al., 2012) process. In this, strategic foresight has learned much from the attention and rigor that design thinking brings to such activities, as observed in Section 1 above and detailed further below. But at the same time, for strategic foresight, the observing phase is built on a much broader foundation, that looks well beyond end-users needs, preferences and pain-points, to include also the contextual forces in technology or regulation or other external social, market or industry changes that surround users. This may come to result in a change of their preferences, or to limit or enlarge their possibilities, or to reveal new pain points. The scanning and learning process, in other words, seeks an overall picture of the scope and extent of external change within and around the user and user communities.

Analysing external change-forces and their potential outcomes as completely as possible addresses the fundamental problem associated with close observation of consumers, including empathy with their preferences and pain points, which is the 'faster horses' problem. It is said that Henry Ford, of Ford Motor Company, when asked about his lack of attention to end-user observations or surveys, commented: "If I had asked *them* what they wanted, they would have said faster horses!" There is evidence that the attribution is apocryphal, but the problem it refers to is paramount in the strategic foresight field: consumers cannot be relied on to envisage "leap" solutions, nor therefore to express need or preference for them. This is to say, end-users will not escape their current mental models when considering future preferences. They cannot reliably be expected to know what technology or other contextual forces may entirely upend the solution field, nor when this may happen. Neither will close observation of their needs and preferences necessarily reveal this.

The implication is that, while close consumer observation and empathy is important, it is not sufficient on its own. Technology breakthroughs, as well as regulatory or industry shifts, for example, may at a stroke render preceding consumer observation and empathy work redundant. No amount of consumer observation prepares the design thinker for end-user preferences in reshaped or "disrupted" sectors. Consumer observation alone is brittle and vulnerable to significant, sudden change. The context surrounding usage and users may suddenly become quite different from that of today. Put another way, the "empathy" and "define" stages of design thinking rest on the assumption that no major disruptive elements will change the solution set during the period being designed for. They assume a more-or-less status-quo context, or constant gradual change along the current path. History shows, however, that this is a highly vulnerable assumption. And it puts vulnerability to disruption, along with the element of surprise, at the heart of the design thinking process, as currently conceived.

In the Ford automobile example referred to above, a combination of new technologies triggered a new mobility system that satisficed greater user need for mobility, and also stimulated new needs. Continuing the theme: shortly after the introduction of the automobile, one of its pioneers, Gottlieb Daimler, observed that "the global demand for automobiles will not surpass 1 million —if for nothing else due to a lack of chauffeurs" (Borg, 1999). With over 60 million vehicles sold every year, and currently an estimated one billion cars around the world, the error of this view illustrates, once again the weakness inherent in a close focus on user needs. Rapid development of ease-of-use standards in operating automobiles meant that the user "need" for a chauffeur was only 'real' until, quite suddenly, it was not.

Solving the "faster horses" problem therefore means anticipating leaps and discontinuities as well as continuities and "evolutions" in this contextual environment. The tools and methods of strategic foresight, detailed below, have been developed specifically to provide this. This requires a different set of evaluative processes that what is currently available in most design thinking tool kits. The tools and methods of strategic foresight, detailed below, have been developed specifically to provide this.

Strategic Foresight

Strategic foresight as a field has emerged since the 1950s. It was pioneered by the French "La Prospective" school (Godet & Durance, 2011), Herman Kahn at the U.S. Rand Corporation in the 1960s, Donella Meadows and the Club of Rome adaptation of systems modelling in the *Limits to Growth* study (Meadows, 1972) in the

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1970s, a decade which also saw early success in use of scenario planning by Pierre Wack and Royal Dutch Shell (Wilkinson & Kupers, 2013). The tools and approaches of the emerging field were extensively categorized by Wendel Bell in the 1990s (Bell, 1997), while the case for foresight in company management thinking particularly was made by Hamel and Prahalad (1994). See also updated reviews of approaches and practices in the field, notably by Hines and Bishop (2007), Rohrbeck et al. (2015), and Iden et al., (2016).

Over this time, there have been many definitions of the purpose and mandate of strategic foresight. For this paper, we adopt the definition by Richard Slaughter (1997), which is broadly representative of the field. Strategic foresight is:

> "the ability to create and maintain a high-quality, coherent and functional forward view and to use the insights arising in organisationally useful ways; for example: to detect adverse conditions, guide policy, shape strategy; to explore new markets, products and services. It represents a fusion of futures methods with those of strategic management."

Although there are many subdivisions and specializations in the field, some generic and foundational positions are evident. First among these is that strategic foresight particularly turns its back on any concept of a predictable future, and on all activities that try to predict the future, including forecasting by data projection and extrapolative modeling. Modeling of past data to predict future outcomes is fatally vulnerable to even small shifts in underlying assumptions (Makridakis & Taleb, 2009), or only reliable under stable, slow-moving change conditions (Courtney et al., 1997). Therefore it is completely inadequate to the task of future thinking in open, complex situations (Cornelius et al., 2005; Cuhls, 2003; Gavetti & Rivkin, 2007; Gordon, 2009), such as those that both future-thinkers and design-thinkers typically face. In its antipathy to prediction of any kind, the strategic foresight field orients itself to future preparedness by way of qualitative, exploratory and narrative tools that expand decision-makers' recognition and perception of plausible outcomes. This allows them to investigate implications and test future solutions (Berger et al., 2008).

Second, and related, the foresight field seeks to broaden our approach to the future from the activity of merely deducing "most likely" or "most probable" future situations. Instead, we are invited to consider less likely but still plausible and possible outcomes, which is valuable both in mitigating surprises, and in drawing attention to assumptions and potential blind spots in decision-making. Third, it is also fundamentally agreed that the purpose of foresight is not simply to build tools for use at a future time, but rather for use today, and to improve thinking about choices in the present moment. Foresight serves this purpose by stimulating perception of alternative outcomes, so as to expand the range and depth of strategic assessment, and therein improve decisions to better fit the future. In this, strategic foresight broadens and deepens the strategic decision-making process from its traditional steps, as diagrammed below. The top line represents the standard predictive planning process and the lower line the strategic foresight.

The lower line emphasizes the need for deeper analysis, and even more importantly, consideration of multiple contextual scenarios and the ensuing alternative strategies. Such alternative strategies also imply alternative innovation systems, for example, in the automobile industry, when considering both car-based mobility, and mobility as a service (where a smartphone provides access to optimal multi-modal mobility, that may include, ride hailing, bicycles, e-scooters, etc.). This emphasis on plurality is key to overcoming the cognitive bounds of actors (Gavetti, 2012), enhancing decision-making quality, and increasing organizational agility (Lehr et al., 2017).

Steps in Strategic Foresight

Over 60 years of practice and theory in the strategic foresight field have provided various encapsulations of the steps that characterize good foresight processes. While there are many such iterations, there is also broad agreement as to necessary steps and best practices. Similarly to the summary of design thinking process above, the brief representations of strategic foresight below should be taken as broadly representative of the field, rather than as a singularly agreed method.

The Association of Professional Futurists (APF), a key scholarly and professional body in the foresight field, defined six steps in achieving strategic foresight competence, after a five year study 2011-2016. This was reported in Hines et al. (2017), based on, and updating, Hines and Bishop (2007). The steps are:

Framing: defining a focal issue and current conditions;

Scanning: exploring signals of change;

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Futuring: identifying baseline and alternative futures;

Visioning: developing and committing to a preferred future;

Designing: developing prototypes, offerings, or artifacts to achieve the vision and goals;

Adapting: enabling organizations to generate options to alternative futures.

Rohrbeck and Kum (2018) have put forward a "3Ps" (Perceiving, Prospecting and Probing) foresight process model, which covers similar terrain, and which is also broadly representative of the strategic foresight process, but extends it with particular attention to the phase of probing, or, in design terms, "prototyping" and "testing" (ref. Stanford D-School model, above.) We will now address this 3Ps model in more detail, before turning to how it may be integrated with design thinking.

Perceiving

Perceiving means identifying evidence of change in the environment external to the organization and seeking to understand and interpret it. Sometimes also known as "horizon scanning", or "environmental scanning", or simply "radar", this is the structured activity of looking for signals that indicate what and where external changes are occurring. These signals are often technological progress events, but may also include social or market changes, or legislative shifts. They may be landmark events that signify important junctures and new trajectories (Ansoff, 1980), or may be peripheral "weak signals" (Day & Schoemaker, 2005), the implications and importance of which are as yet unclear. When examined, many "surprises" have clear antecedents, and the perceiving phase creates vigilance to such. Attention to parallel sectors or across geographies is also intrinsic to the process because scanning rests on the concept that "the future is already here, it is just unevenly distributed" (a quote attributed to the science fiction writer William Gibson). Scanning sometimes uses the mnemonic STEEP or PESTEL (political, environmental, social, technological, economic, legislative) to prompt the necessary width of coverage through which the process gains value. In some cases, there is payoff for an organization to identify such signals ahead of competitors, therein gaining a lead-time advantage. But more often the benefit of the scanning process comes in orienting leadership attention towards developing threats or opportunities in the external environment, rather than being lulled into a "business-as-usual" view of the future.

Further, a properly managed perceiving phase would also recognize, "while it's one thing to look, it's another thing to see". In other words, the process of perception demands attention to the perceptual frames that the viewer inescapably brings to the perceiving process. Such frames or "paradigms" or "mental models" are made up of embedded assumptions, heuristics, or biases, that cause scanning evidence to be mentally filtered in or out, or only partially recognized, or interpreted in a weighted or skewed way (Gavetti & Rivkin, 2007). While there can never be a "pure"

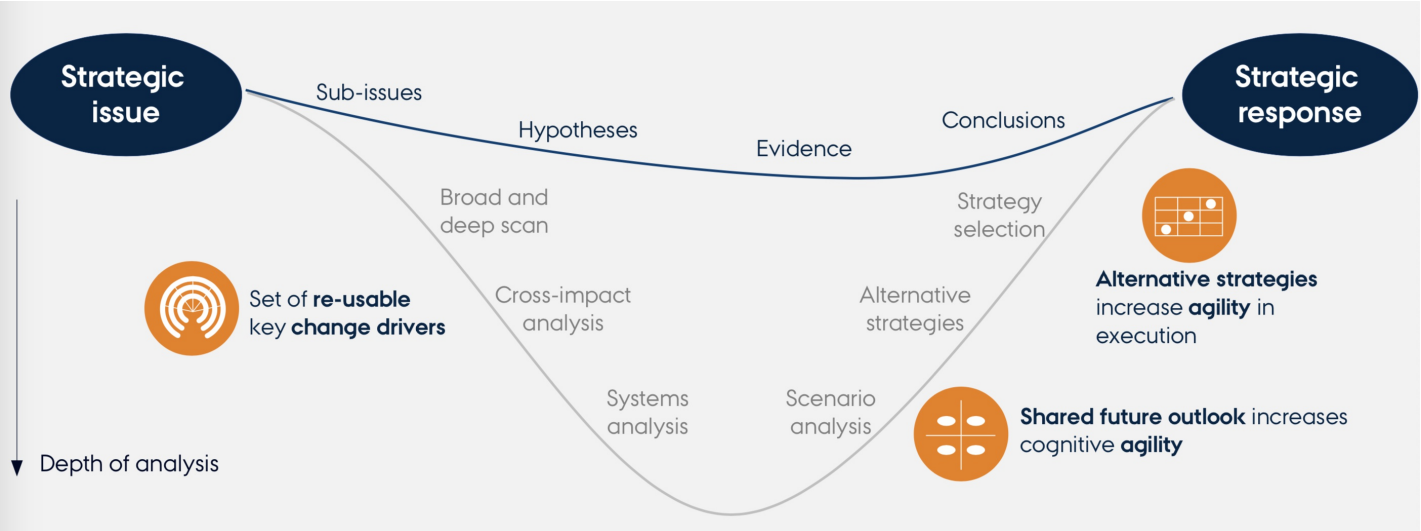

Figure 2: Strategic Foresight vs. the Traditional Strategy Process. (Rohrbeck, Etingue Kum, Jissink, & Gordon, 2018.)

perception, the conscious bias of self-questioning calls attention to the perceiver's cognitive foundations and limitations, including the very common tendency to notice more prominently and value more highly information that accords with one's own view. Likewise is the tendency for perception to norm to a widely held group viewpoint, or to conform with a judgment previously made or invested in.

Prospecting

Once signals and data are gathered, various activities are used to make sense of them, to understand their patterns and the implications for change (Daft & Weick, 1984). The prospecting phase refers to the practices of (a) making sense of the many signals that perceiving captures, towards formulating an informed and reflective understanding of the present and expected future as pertains to the particular issue or situation under study, and (b) casting forward to create non-predictive narratives or hypotheses of the various important ways the future may unfold. The first practice is achieved in part by assembling the data over time to the present time. This provides trend recognition, as well as understanding of the presence or absence of future validity in these trends (Gordon, 2010). Prospecting is also achieved by investigating the systemic forces and feedback loops that structure and limit change in the situation under study (Meadows, 2008), and further by exploring the deeply held beliefs, myths and metaphors (Inayatullah, 1998) that underpin contemporary societal representations. Likewise, these practises pay attention to various preferred or aspirational activities (Godet, 1982; Ogilvy, 1992) that different stakeholder groups have, as well as their relative power to enact these.

With as robust as possible an understanding of the present, strategic foresight turns mentally casting forward into the future in a non-predictive way. This may include applying a variety of methods among which are Delphi studies (Dalkey & Helmer, 1963), cross-impact analyses (Helmer, 1977), futures wheels (Glenn & Gordon, 2009), or technology road mapping (Phaal et al., 2004). Systems dynamics also has a role here, in helping future-oriented thinkers to understand why some events may have large or even exponential change implications and others lead to no change at all. Likewise, in explaining lag between change forces and their subsequent effects (Sterman, 2001). This process sometimes takes the form of "backcasting" (Robinson, 1990), that is, filling in backward from a potential future outcome in order to show how the present may happen to reach that outcome, including actions innovators may make to bring it into being if they have the institutional or industry power to do this (Thorén & Vendel, 2019). Backcasting therein illuminates necessary decisions, resources, capabilities, (and in this context, design innovations) required to reach towards a specific future end-state.

Among forward-thinking tools, the most commonly used and best known is scenario planning. Scenarios are narratives of what the future may look like (with reference to the situation or sector under study) given particular foundational assumptions and a particular path of evolution (Durance & Godet, 2010). The point of

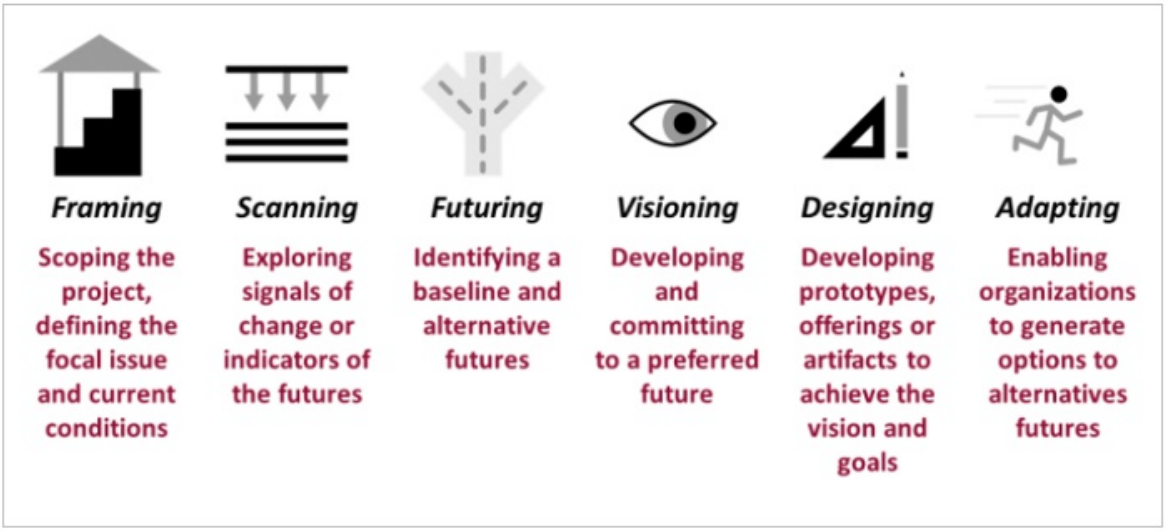

Figure 3: Steps in Strategic Foresight. Association of Professional Futurists. apf.org

scenario planning is to vary these assumptions and paths so as to create a spread of alternative future narratives none of which is predicted, but which are all plausible. Each of these scenarios has different implications for the organization, therein challenging management thinking (Gausemeier, et al., 1998; Schoemaker, 1993). Generally, scenario time horizons will be circumspect, in the range of 5 to 15 years, though longer views are not uncommon. Longer time horizons sacrifice immediacy, but relax the strictures of "what is possible" and so invite and enable stretch thinking. One of the early proponents of scenario planning, Herman Kahn, referred to scenarios as "thinking the unthinkable" (Kahn, 1960), that is, giving specific attention to outcomes at the limits of plausibility. Scenarios are built to provoke thinking and stimulate conversations, that is, to "ideate" in design thinking terms. Chermack & Coons (2015) have viewed them as thought trials or trial balloons which work in the same way design prototypes do: inviting speculation, feedback, and learning. Thought trials (Weick, 1989) are a set or series of conjectures about a variety of possible solutions to a given problem.

Probing

Whether they are fully materialized beyond scenario form or not, views of the future can be turned into decisions, innovations and strategies in various ways. They allow decision-makers to assess whether their current or imminent plans are robust across different plausible contextual situations (van der Heijden, 1996), and what opportunities and threats a non-continuous future may present. This suggests innovation of products, services or solutions such as may be required (Mietzner & Reger, 2005). A future different from today, and from what is commonly anticipated, often stimulates bridge-thinking: "What would be needed in this scenario? What problems will users or society as a whole face, and how may these be resolved? What are the new opportunities and how might these be provided, or sourced, or built? Who would 'win' in this scenario, why and how?" All of these questions are asked in the face of a particular plausible. All of these questions, when asked in the face of a future scenario, may provoke innovative and imaginative leaps whose use is not necessarily confined to that scenario.

If the idea passes tests of initial interest and internal approval, a company may develop a "probe" study to investigate how it might be given concrete shape, and be brought to user and market readiness (Gausemeier et al., 1998). Probing aims at testing and legitimizing a new course of action, and preparing the ground for scale-up and roll-out. But it stops short of full roll-out of the solutions that would commit the company to the solution before the plausible future in view actually manifests. Probes stimulate and gauge user feedback, and create a learning cycle of iterative refinement of the product or service with users, that is, via probing, firms move from "cognitive search" to "experimental search" (Gavetti & Levinthal, 2000). Probes may include R&D projects or acquisitions, product or service prototyping, internal venturing, experimenting in trial markets, creating intrapreneurship units or internal venture funds, "accelerator" units running consumer tests, and so on (McGrath, 2001, Michl et al., 2012, Rohrbeck et al., 2009).

Towards a Foresight-Informed Design Thinking

When placed in a side-by-side comparison, it is apparent that the probing phase of strategic foresight has much in common with the prototyping and testing (build-to-learn) phases of design thinking. This overlap and congruence is no accident. Strategic foresight theorists and practitioners have absorbed build-to-learn into their approach over the past decade, based on exposure to design thinking. There is now also a common call for "ethnographic" approaches, characterized by listening to end-users and creating a learning cycle with them. For example, Day & Schoemaker (2016) advise "probe-and-learn" experimentation in the foresight process, by which they mean rapid prototyping or quasi-experimental designs that explore new strategic initiatives and pave the way for sequential investments. This requires "a willingness to be immersed in the lives of current, prospective, and past customers [and] exploring and identifying latent needs or learning from lead customers." (Ibid)

Foresight has also embraced the benefits of "rendering." This means giving tangible form to concepts as a way of exploring and refining them, either in the probing phase or in constructing future views themselves. It is not uncommon for scenarios these days to be rendered, that is, manifest in visual or assembly form, rather than narrated. Also, in congruence with the processes and culture of design thinking, strategic foresight is almost always created in groups, via a "messy" process that values heterogeneous expertise and diversity of inputs. Notably, in activities such as these, foresight also joins design thinking in viewing its methodological rationale as "a craft" that guides practitioners towards ideas and improvements, rather than identifying as a scientific process that produces "answers." As with all crafts,

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despite an overall lack of methodological exactitude, a set of firm, underlying, repeatable principles that lead to better outcomes is held as common knowledge. It takes skill, practice and experience to execute these.

Building on these many commonalities, the processes of strategic foresight may be harnessed in the service of producing design thinking outcomes that are future-informed and future robust, as follows:

a. Scanning for external change factors that goes beyond attending to the end-user, therein considering the full force-field of external change influencing a particular situation. Such scanning includes orientation both to weak and strong signals, and also clear attention given to perceptual frames and biases. The benefit is that the design thinker will be able to anticipate contextual changes that the common end-user is unlikely to be aware of, and that observation of or empathy with that user will not necessarily reveal.

b. Creating a high-quality understanding of the present, and critical view of the expected future. This involves sorting and evaluating change forces, recognizing trends, and considering in what ways and how strongly they may drive the future. It therefore also implies evaluating the force and longevity of these trends rather than merely assuming continuance of their past

Table 1. Design Thinking and Strategic Foresight

Design Thinking process. Representative model: Stanford D-School	**Strategic Foresight process Representative model: Three P's Framework**	**An Integrated, Foresight-informed Design Thinking process**
1. Empathize Observe users' preferences and discover their needs, both overt and latent. This is also described as need-finding or deep "listening", or as undertaking a learning journey to tune into users' behaviours, preferences, and needs.	1. Perceive: Scanning Look for signals that indicate changes occurring in the external environment. Address the full force-field of change that will influence future outcomes within the relevant domain. This activity includes giving attention to and mitigating perceptual frames that degrade observation.	1. Empathize and Perceive Attend to user observation and empathy, but also expand observation to include scanning the full force-field of change factors in the external environment (while addressing the limits of perceptual frames in both activities).
2. Define Consolidate insight into what the core problem is to seeks a solution, or opportunity to be pursued.	2 Prospect (a) Sensemaking Interpret the evidence from the perceiving phase, understand its patterns, and build an informed understanding of the present, including implications for change. This involves sorting and evaluating change forces, looking at the strength of trends and to systemic, cultural or political forces that facilitate or block change. Prospect (b) Futuring Cast forward to create non-predictive narratives investigating alternative plausible future outcomes. This step involves fleshing out or otherwise reifying the different ways that important external forces may change the contextual environment. Key assumptions and development paths are varied, to create alternative future narratives to alternatives outcomes, each of which has different and important implications for design decision-making in the present.	2. Prospect then Define Interpret the evidence from the Empathize and Perceive phases, to build an informed understanding of the present, both from the user point of view and with reference to macro-externalities and potential leap solutions. Advance this understanding into alternative views of the future non-predictively, within which to consider the design problem. Therein develop a robust view of plausible future contexts that the design thinking process is addressing. Once this basis is achieved, define the design problem to be addressed or opportunity pursued.
3. Ideate Develop a wide range of solution ideas to the problem or opportunity defined.		3. Ideate Develop a wide range of solution ideas to the problem or opportunity defined. In addition to standard design ideation, use non-predictive alternative views of the future, containing alternative users and different needs, to stimulate and enhance ideation.
4. Prototype Narrow the product or service ideation toward an early solution, rendered as a sketch or early working model, allowing it to be appraised and improved.		4. Prototype As before, narrow the product or service ideation toward one or a small number of prototypes.
5. Test Follow an iterative process with users to learn what works, modifying the prototype until it is ready to move to final phase and scaled-up.	3. Probe Select from and test new courses of action via a process of experimental searching that looks for tangible proof of the potential success of new ideas and iteratively refines the emerging solution.	5. Probe and Test The iterative probing, testing, and refining step proceeds as before.

trajectory, and attention to underlying systems that facilitate or block change, as well as to the power dynamics among different stakeholders who may have different future aspirations and capacity to bring this into being. The benefit to the design thinker is in arriving at a sophisticated view of the future that the design-thinker is attempting to create for, and therefore which designed solutions are more vs. less likely to find adoption with users in the future.

c. Investigating alternative plausible futures. This involves structured thought experiments, most commonly in the form of scenarios, to investigate different ways the external context relevant to the design thinking challenge may change. Note that scenarios here are not about how a decision or a design experiment may play out. They are rather about the ways the contextual terrain in which the design has to function in the future may differ, which will make different demands of the design. With various scenarios in hand, the design thinker escapes the trap of designing for the present, a "most probable" future context, or a hoped-for future context, and is instead thrust into apprehension of alternative contexts. This either stress-tests current design solutions for robustness, or presents different outcome situations that stimulate ideation (or both.)

The following table describes the parallel processes of design thinking and strategic foresight, and how they may be brought together to create a future-informed, design thinking process.

Conclusion and Implications

The purpose here has not been to amalgamate design thinking and strategic foresight. These are different methodologies, set up to resolve different types of problems and achieve different goals, and should remain so. Our purpose instead has been to document and expand our understanding of the many intrinsic commonalities between the two fields, and their associated methodologies, already recognized and applied in strategic foresight, and to insert this understanding into the design thinking process. For this purpose, we have discussed the benefits of strategic foresight, and argued that this takes design thinking beyond reliance on user observation, and therein helps to mitigate its vulnerability to significant or unforeseen contextual changes. We have also shown that sense-making and prospecting in the arena of contextual change, and casting this forward in non-predictive scenarios, may also in itself be a basis for innovative thinking. We have also shown that sense-making and prospecting in the arena of contextual change, and casting this forward in non-predictive scenarios, may also in itself be a basis for innovative thinking. The aim is that this may feed into innovation processes and innovation management, and also provide a source of advancement for design thinking.

Beyond demonstrating motivation for and benefits of inserting strategic foresight methods into the design thinking process, we have also attempted to demonstrate how this can be done. For this purpose, we brought a side-by-side comparison of representative models from each field, and showed how these may be assembled together in practice to create foresight-informed design thinking. The suggested framework brings academically and practically validated strategic foresight processes to design thinking, while also respecting the integrity of the design thinking model as-is, thus adding to it rather than seeking to revise it. Practically speaking, design thinkers and innovation managers now only require the motivation to insert strategic foresight into their ideation and innovation processes, and they will find a framework available for them.

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Escaping the 'Faster Horses' Trap

Adam Gordon, Rene Rohrbeck, and Jan Schwarz

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About the Authors

Adam Gordon is Associate Professor at Aarhus University School of Business and Social Sciences, Denmark, and leader of its Strategic Foresight Research Network. He is the author of *Future Savvy*, American Management Association Press, and posts on future strategy in the management press at forbes.com/leadership. He is on the editorial board of *Futures and Foresight Science*, and co-editor of a special foresight and innovation issue of IEEE *Transactions on Engineering Management*.

René Rohrbeck is Professor of Strategy and Continuous Innovation at EDHEC, France. He is author of *Corporate Foresight: Towards a Maturity Model for Future Orientation of a Firm*, Physica-Verlag. His editorial record includes being the managing editor of the special issue on *Corporate Foresight for Technological Forecasting & Social Change*. He is on the editorial board of *Futures* and *Foresight Science*, and co-editor of a special foresight and innovation issue of IEEE *Transactions on Engineering Management*

Jan Oliver Schwarz is Professor of Strategic Management at ESB Business School, Reutlingen University, Germany. He is a researcher and advisor on corporate foresight processes, strategy development, and business wargaming, and is co-author of "Business Wargaming: Securing Corporate Value," Routledge.

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How to Develop a Digital Ecosystem: a Practical Framework

Omar Valdez-De-Leon

> *"Our philosophy is that we want to be an ecosystem. Our philosophy is to empower others to sell, empower others to service, making sure the other people are more powerful than us. With our technology, our innovation, our partners - 10 million small business sellers - they can compete with Microsoft and IBM."*
>
> Jack Ma, CEO of Alibaba

Throughout the modern industrial era, industries have generally been organized as linear value chains. This gave birth to the vertically integrated organization, which was organized in such a way in order to control the entire value chain and achieve economies of scale, which in turn would create a significant competitive advantage. As digital technologies continue gaining adoption, they start enabling new ways of organizing how value is created. This transition means moving from value chains to digital ecosystems.

This is giving way to new industry giants, which rely on the strength of their digital ecosystems to attain market dominance. However, there is still limited knowledge of digital ecosystems: how they are created, how they work and, importantly, how organizations beyond digital giants can approach digital ecosystems. Based on literature review and expert surveys and interviews, this piece puts forward a practical framework for both established organizations and entrepreneurs to better understand, plan and navigate the new paradigm of digital ecosystems.

Introduction

Throughout the modern industrial era, industries have been organized as linear value chains. This gave birth to vertically integrated organizations and giants such as Exxon Mobile and Royal Dutch Shell that were designed in such a way to control the entire value chain. The purpose of this was to achieve economies of scale that would create an important competitive advantage.

However, things are changing . As digital technologies continue developing and gaining adoption, they start enabling new ways of organizing how value is created. This means a transition from value chains to digital ecosystems. This in turn is giving way to a new type of enterprises, such as Apple and Alibaba, that rely on the strength of their digital ecosystems to attain market dominance.

And even though these are widely discussed cases, there is still limited research and knowledge of digital ecosystems, including how they are created and how they work.

This study and resulting framework is a response to the needs to better understand such ecosystems and to help organisations and practitioners going (or planning on going) though such transition. The aim is to shed some light on what these digital ecosystems are, how they are built in practice, and how practitioners can approach them. To this end, a framework has been developed that can provide reference to a practical approach, including key levers that can be used to create, develop and engage with a digital ecosystem. The framework, developed using literature review and an expert panel survey approach, is described in this article.

It is sometimes argued that 'not every organization can build its own ecosystem like Apple or Amazon'. And this is largely true, at least in terms of scale. However, if ecosystems are the new way of organizing value creation, then every organization and every

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entrepreneur should know how they work, at a minimum to be able to better participate in them. Moreover, the author believes that there is not such a thing as a single type of 'ecosystem'. Instead, there are different kinds of ecosystems. Some are small and others large. Some ecosystems are part of larger ones. Some overlap. Some are global; others local. Some operate in a niche, while others are market specific.

For example, there are global ecosystems like those of Apple or AirBnB. There are also industry-specific ones like those Verifone and Klöckner are developing. Likewise, also small, local or niche ecosystems like To Good To Go, whose app connects local businesses and consumers to make unsold food available at reduced prices to cut food waste. Too Good To Go is part of both the iOS and Android ecosystem. Yet it also has its own ecosystem of vendors and consumers, who in turn participate in other digital ecosystems. As such, from the results of this article it is fairly safe to say that every organization needs an ecosystem strategy.

The paper is structured as follows: First, I provide a basic definition for digital ecosystems. A short description of the role of digital ecosystems in industry value creation then follows. Following that, I outline the current need for a practical framework that helps companies tackle the transition to a digital ecosystem, then describe the methodology used to develop this framework. Finally, I describe the framework for building digital ecosystems and recommend the framework's use and further development in the conclusion.

What are Digital Ecosystems?

Defining Digital Ecosystems

Business ecosystems have been continually defined, re-defined and studied over the past 20 or more years. (Moore, 1996; Iansiti and Levien 2004; Muegge, 2013; Jacobides et.al., 2018). In their work, Iansiti and Levien attribute the business dominance of Walmart and Microsoft to the success of their respective business ecosystems. They define these ecosystems as "loose networks of suppliers, distributors, outsourcing companies, makers of related products and services, technology providers, and a host of other organisations that affect and are affected by the creation and delivery of a company's own offering" (2004).

More recently, Jacobides (2019) defines digital ecosystems as "interacting organisations that are digitally connected and enabled by modularity, and are not managed by a hierarchical authority".

For the purposes of this paper, I propose a definition of digital ecosystems as, "loose networks of interacting organisation that are digitally connected and enabled by modularity, and that affect and are affected by each other's offerings".

The Role of Digital Ecosystems

Iansiti and Levien (2004) suggest business ecosystems create value to the end consumer by leveraging a symbiotic relationship whereby platform owners (for example Microsoft) enable others (for example software developers) to create products on the (Windows) platform, that have the potential to strengthen the (Windows) ecosystem, thus giving everyone involved "a collective advantage over competing networks". This way, value is mutually created both to the end consumer, the platform owner and ecosystem participants. Every participant in the ecosystem benefits from interacting within the ecosystem and thus is incentivized to keep participating.

This implies a move away from creating value through only one firm's integrated value chain, towards creating value by many firms enabled and orchestrated by a platform. This has been described as an 'inverted firm' (Van Alstyne et.al., 2016; Van Alstyne, 2019), which in turn helps to increase the total value created.

One contributing factor that facilitates this inversion is the effect that digital technologies can have on reducing transaction costs between independent parties, making 'buying' more desirable than 'making'. Here I borrow Ronald Coase's concepts related to the nature of the firm. Indeed, digital technologies can help reduce a company's transaction costs (through modularity, for example. See also, Iansiti and Lakhani, 2017, regarding how blockchain could contribute to this too). This means that the cost of sourcing products or services through third parties can be lowered, making it more practical and cost-efficient to work with external partners instead of trying to do everything in-house. It can be not only more practical, but also a more strategic decision, in order to keep pace with the degree of innovation enabled by digital technologies and the rapid change of entire industries (Gawer, 2009b; Gawer and Cusumano, 2014; Van Alstyne, et.al., 2016). Indeed, research by McKinsey estimates that companies with an ecosystem approach have higher earnings than those without (Bughin, et.al., 2019). These findings suggest that the emergence of digital ecosystems signifies the declining importance of value chains, and at the same time the increasing importance of digital ecosystems (see Figure 1).

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Importantly though, an ecosystem is more than a set of partnerships. Since it is a network of loose contributors who interact closely to create mutual value, there is necessarily an atmosphere of interdependency among partners in the ecosystem. This means that all partners share the same interest and that individual partners will only be successful if the ecosystem succeeds (Iansiti and Levien, 2004). As such, business and operating models need to be adapted to the new paradigm.

The Risk of Not Taking Part in the Digital Ecosystems Paradigm

The main risk for a company of not taking part in digital ecosystems or not even having an ecosystems strategy is getting left behind. As ecosystems become more entrenched and capture more of the available markets, those businesses outside may find it hard to compete (Gawer, 2009a).

Also, ecosystems tend to expand beyond their initial sphere. This means that new market entry may not happen through individual innovators, but rather through an entire ecosystem that leverages its existing market power, technology and reputation to move into an adjacent market (Gawer and Cusumano, 2008). Take for example, the case of Nokia losing its dominant position to new entrants that took an ecosystem approach. Also, more recently, Apple has entered the music streaming market and is gaining market share from Spotify by leveraging its market power in mobile devices, operating systems and distributing applications (Apple Store).

As the trend toward ecosystem thinking continues, organizations are almost bound to at least in some way become part of an ecosystem. This ultimately makes ecosystems into a kind of competitive unit, wherein competition for market share takes place between ecosystems, rather than between individual companies. Also, there will not be a single, but many interlinked ecosystems, or an "ecosystem of ecosystems" (Valdez-de-Leon, 2017). This means that every business organisation and entrepreneur needs to gain a better understanding of how to approach digital ecosystems.

Towards a Practical Framework for Developing Digital Ecosystems

The Need for a Framework for Developing Digital Ecosystems

Moving to an ecosystem model, however, can be difficult, especially for incumbent players with well-established operations. Such a model involves a different approach and, more concretely, a new set of strategies, processes, competences and technology assets. In a recent interview, the SVP of IoT at Sprint, a major Telecom operator in the US, explained how telecom operators are struggling to transition from serving the single-service consumer market to the myriad of new applications that form part of the Internet-of-Things (IoT) ecosystem. This involves having to develop a new technology platform that will attract and maintain relationships with developers that can help Sprint develop its ecosystem (Rook, 2019).

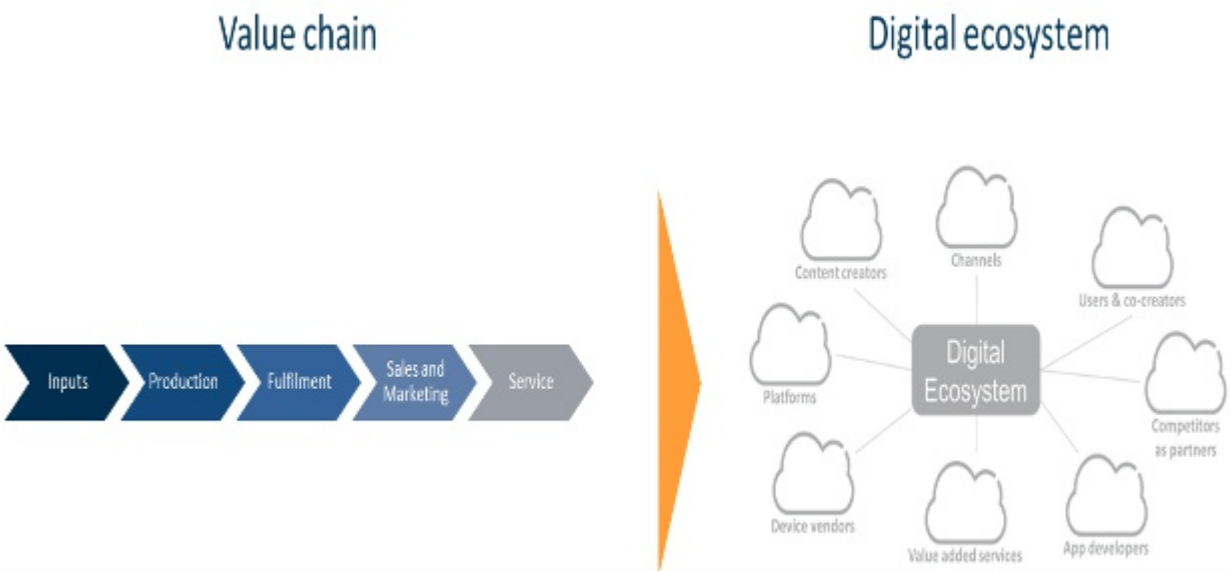

Figure 1. The transition from value chains to value ecosystems

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Gaps in the Literature

The literature in the subject of digital ecosystems is sparse, with varied areas of focus. Indeed, in recent research Senyo, et. al (2019) map out the research landscape within the topic of digital business ecosystems. They identify a gap in frameworks and other artefacts for such ecosystems. They do identify some efforts in this area with focus on themes such as the interoperability in ecosystems, their integration, enterprise agility, self-organisation, the effect of ecosystems on financial inclusion and overall technical platform development. Other efforts towards framework development include Gawer's (2014) focus on integrating economic and technological views, and Jacobides et. al. (2018) on the various structures of ecosystems that are created based on different types of organisational complementarities.

However, there is a general lack of blueprints or frameworks that can, in a practical manner, help practitioners navigate the digital ecosystems paradigm. A practical framework to develop digital ecosystems and digital ecosystem strategies that fills this gap is thus necessary. The framework put forward herein intends to fill this vacuum.

The next subsection will describe the methodology used to construct the framework, before giving way to the final section that describes the framework's structure and components, and how the framework can be used in practice.

Developing the Framework

Methodology

In developing the proposed framework, a three-part approach was used:

1. An initial characterization of the framework
2. A review and refinement of the framework by an expert panel
3. Final definition of the framework

Initial Characterization of the Framework

The initial characterization of the framework involved a comprehensive review of the relevant literature, case studies and discussions with experts and practitioners in the field. This then formed the basis for a set of three key elements of digital ecosystems as well as six enablers (or levers to shape the three key elements) as depicted in figure 2.

The idea behind this structure was not just to establish the key elements that constitute digital ecosystems (the 'what'), but to focus primarily on the practical enablers that affect and shape these elements (the 'how').

Reviewing, Refining and Validating the Framework

Next, a panel of experts in the field was formed and an initial characterisation of the framework put forward to the panel. They were then asked to review and help refine the components of the framework and also to elaborate on their own practical experience with digital ecosystems.

This process was carried out in three steps (see Figure 3). First, a structured questionnaire was administered to the expert panel to gather their insights, critiques and recommendations. This part produced wide-ranging input into the framework, particularly in the detailed characterisation of the six enablers. Following this, in-depth interviews were carried out with four experts from the panel to gather further insights on practical uses of the framework, which led to a final version.

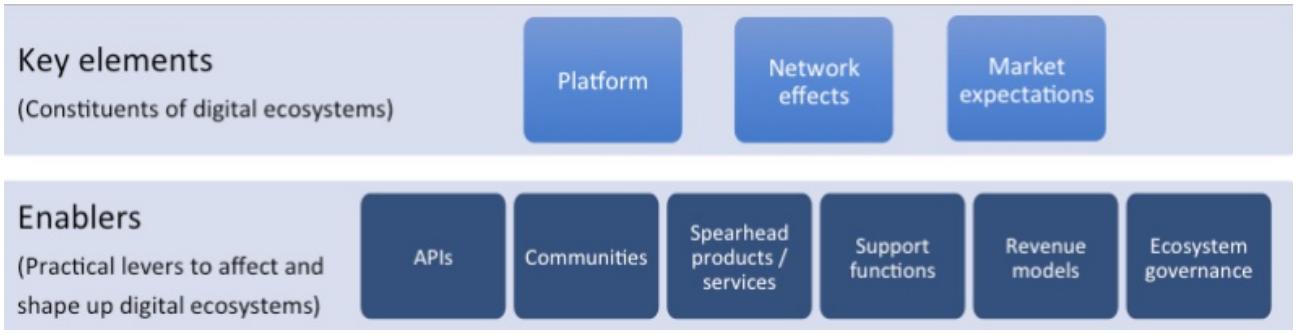

Figure 2. The initial, high level characterization of digital ecosystems

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The Framework

Following assessment and validation by the panel of experts, the framework for developing digital ecosystems is presented below.

There are three main elements for building a successful ecosystem. These are: a platform, network effects and market expectation (as shown in Figure 4).

Three Key Elements

The Platform

This is the key building block of the ecosystem; the enabler upon which ecosystem partners can build their products or services. As one of the experts suggests, "It all starts with a platform. If you do not have a platform you cannot have an ecosystem." Crucial aspects here include openness, modularity and quality as perceived by the ecosystem. Openness means that the platform allows access to platform resources (via APIs, for example) enabling ecosystem participants to develop their own use cases. Modularity is a key driver to developing digital ecosystems as it enables different organizations to build complementary products or services. Quality means features that enable high availability, reliability, and security, which can be highly valued by ecosystem participants. This in turn will help attract other participants to the ecosystem.

The platform in turn supports the other two elements below.

Network Effects

The second element concerns the self-perpetuating cycle of ecosystem participation and user enrolment. More participants and products or services on the platform lead to more end-users attracted to it. At the same time, more end-users on the platform attract more participants with their products and services (Iansiti and Levien, 2004; Gawer and Cusumano, 2008; 2014. Valdez-de-Leon, 2015, 2017, 2018; Van Alstyne et.al., 2016; Van Alstyne, 2019).

Ecosystem leaders need to be able to create the right incentives (financial and other kinds), as well as systems to support participants. They must define how theirs, and not competing ecosystems, will create more value for users and ecosystem participants (Valdez-de-Leon, 2015). Here the emphasis is on creating and sharing value across the ecosystem. This is a challenging task for many organizations that are not accustomed to a

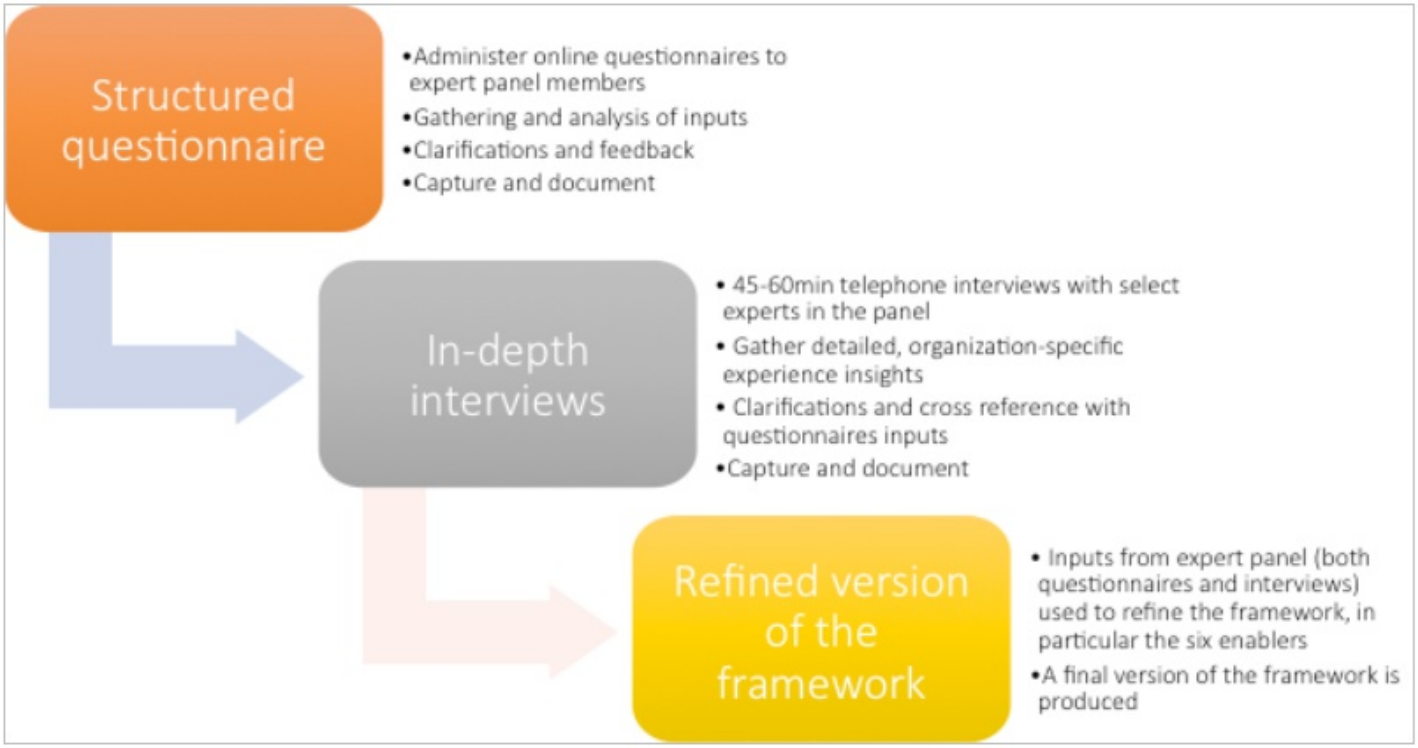

Figure 3. Approach to reviewing, refining and validating the framework

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dynamic where users' value is created and shared across partners in the ecosystem, rather than just within one company.

Two key dimensions to foster network effects: business and operational. The former is related to how value is generated and shared amongst partners. Clearly ecosystem leaders, together with ecosystem participants, need to create value for end-users, and in turn generate revenue for everyone involved. An ecosystem strategy needs to have a well-defined view of how this revenue will be shared. Incentives for the ecosystem to develop also need to be made clear from the start. In addition to fair revenue splitting, these incentives can include elements such as gaining access to market channels, as well as sharing marketing resources and technical support. On the operational side, company leaders need to develop specific capabilities to support the rapid expansion of their digital ecosystem.

Market Expectation

Market expectation is related to how prospective users perceive an ecosystem in terms of its potential to become widespread in the long term. Indeed, participation in an ecosystem is "based not on the network's current scale, but rather on the number of users with whom they expect to be able to interact in the future" (Eisenmann, et.al., 2007). A new platform must satisfy user concerns by building credible expectations for its future success (Edelman, 2015). In a way, building credible market expectations is the first push to get the flywheel rolling towards a network effect.

This is arguably one of the reasons why the Windows phone, as a mobile operating system, failed. Nokia and Microsoft could not create sufficient market expectation among both users and app developers to launch their ecosystem. As a result, they ended up losing to Apple iOS and Goggle Android.

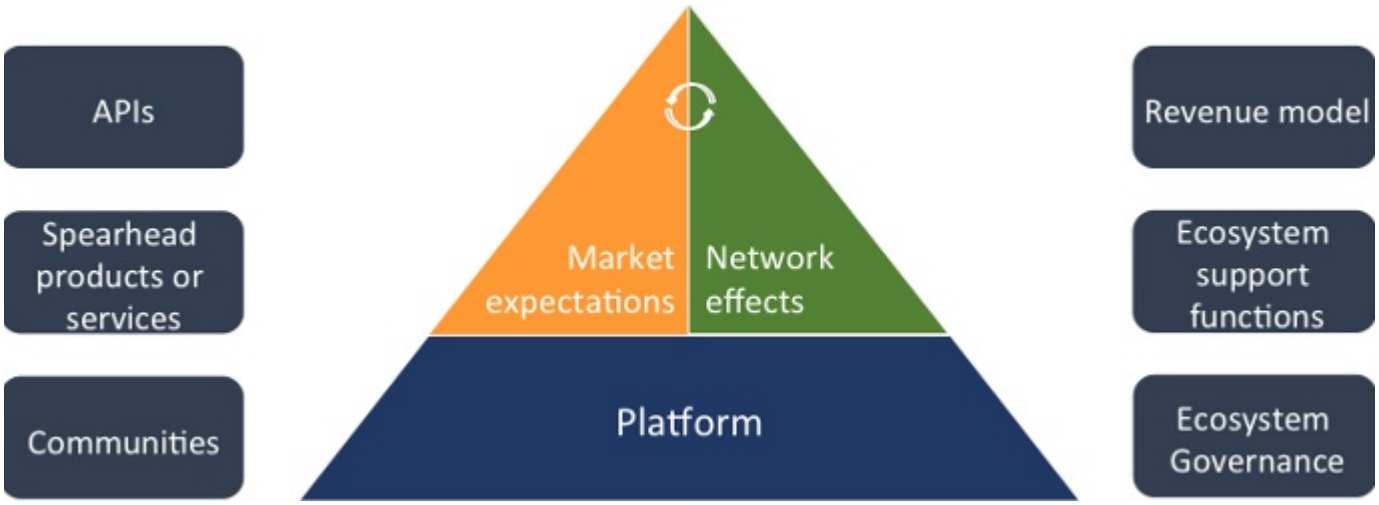
To shape up market expectations, organizations developing a digital ecosystem have several options. First, they can signal commitment by setting up digital units and investing in platforms. They can launch specific (spearhead) products or services to reinforce commitment and to kick-start their ecosystems. Setting up an initial set of partnerships in support of the ecosystem is essential to further grow market expectation (Valdez-de-Leon, 2015).

However, the key question is how to build and activate these three elements. For this, a specific set of enablers can be utilized to develop these elements, which I briefly describe below.

The Enablers of Digital Ecosystems

Application Programming Interfaces (APIs)
APIs are the basic building blocks of a digital ecosystem; the key elements that enable modularity and openness. A robust API strategy is thus required. This strategy should be based on a deep understanding of the markets that the ecosystem intends to serve. Designing APIs for all purposes is impractical, which means that a focused approach is likely to be more appropriate. The ecosystem leaders should also develop an API roadmap that is in line with their overall ecosystem strategy, while the API pricing and support model must be

Figure 4. The key elements and enablers for developing digital ecosystems



aligned with the ecosystem revenue model.

APIs can be used to foster network effects. If using the APIs is too onerous or does not create sufficient value, ecosystem participants will be reluctant to invest time or effort. It is therefore vital that APIs are designed with participants' needs in mind. As one panel expert with a community of more than 70,000 developers puts it, "developer experience is currently the number one consideration. There are so many platforms. If you don't make it easy for your users it will not be adopted". Furthermore, according to the panel, things to consider when developing APIs include transparency and communication with the developer community, good quality documentation, ease of use, steadiness and dependability (not constantly changing), use of standards and long-term support.

A good example of this is the approach taken by Stripe, a US-based company whose platform enables payments over the internet. Their approach from the start was to build their platform with developers in mind, whereby their APIs would be simple, well-documented and steady, so that "developers who integrated the Stripe API would not need to touch it for years", and that it be done by just a couple of developers (Armstrong, 2018). According to Armstrong, the company counts the likes of Facebook, Lyft, Asos and Salesforce among its ecosystem partners. It is valued at USD20bn with around 80% of US internet users having passed through the Stripe ecosystem in 2018. The company has used APIs to propel its network effects by focusing not only on building its credibility (market expectation) among the developer community, but by providing all necessary support (see support functions below) to drive developer adoption and advocacy.

Communities

For ecosystems to work properly, communities of participants need to exist. These participants should be able to develop products and services based on platform resources (via APIs). Experts in the panel observed some key considerations in developing an ecosystem community, which include the need, 1) to establish a fair and clear intellectual property model whereby third party developers can fairly monetize their developments, 2) to open up the platform to a sufficient degree to allow and encourage innovation, 3) to 'create community' in the sense of enabling the exchange of ideas and fostering collaboration, and, 4) to provide an open door for feedback from the community about the position and direction of the ecosystem in the market.

The community benefits can be significant as in the case of Stripe. By enabling people to invest and create new products and services on the platform, the ecosystem can provide a richer set of options to end-users. Moreover, the faster an ecosystem develops a positive reputation among developers and thus more join the platform, the more difficult and onerous it becomes for others to replicate such a deed. This reflects market expectations driving network effects. As more developers are attracted to the ecosystem, more users are drawn to new products and better services offered.

Spearhead Products or Services

The launch of 'spearhead' products or services is another essential driver of ecosystem development. These are products or services that ecosystem leaders develop either themselves or through third parties, on top of their platform, in order to target a particular segment of the market. This approach helps develop market expectations by signalling commitment. It shows that the ecosystem leader is committed and ready to "put money where their mouth is". However, the real power of spearhead products or services is that they create a customer base that can help kick-start the ecosystem (Valdez-de-Leon, 2018). One way to visualize this is to look at how the video games industry relies on one or more key spearhead games (think Call of Duty or the Mario Bros series) to drive early user adoption to consoles, which helps attract developers to the platform and in turn brings in even more users (network effects).

Here the key challenge for an ecosystem leader is to define the right product or service that can become a 'killer app', as well as how to build it when the needed resources and skills to develop it might not be available internally. Here is where the developer community becomes a key resource. For example, Apple is reportedly commissioning new original content (TV shows, movies, podcasts) as a competitive tool to expand its customer base and in turn attract new content creators in those new categories to its ecosystem (Shaw and Gurman, 2019). This is essentially another lever to drive the tandem of market expectation and network effects.

Another consideration raised by the panel in regards to spearhead products is to be careful in their selection, as ecosystem leaders can risk alienating ecosystem

partners by launching products that directly or indirectly compete with theirs.

Support Functions

Ecosystems need to be continually supported, after first being created over a period of time. This is obvious yet often underestimated (Valdez-de-Leon, 2018). Support functions are essentially the internal organization and related functions that provide support to ecosystem participants. This capability goes beyond arms-length partnership agreements. Experts in our panel concurred that dedicated teams are invariably required to support an ecosystem. This support includes technical (for example, how to use an API like Stripe does), marketing (for example, how to sell your apps on our marketplace) and operational support (for example, "fulfilled by Amazon" logistics support services). Experts in the panel suggested their organisations have been offering developers things like a dedicated developer portal with SDKs (Software Development Kits), documentation and other forms of online help. Self-service and peer support through online forums add additional value. Marketplaces like Verifone's also offer app certification services, app design guidelines and a channel-to-market for developers through its app marketplace.

Revenue Model

The revenue model constitutes a key feature of a successful digital ecosystems development undertaking. Ecosystem leaders looking to attract ecosystem participants need to define the right revenue generation and allocation model, one that incentivizes participants to join the ecosystem at an early adoption stage, whilst reducing their risks to innovate (Valdez-de-Leon, 2015; Van Alstyne, 2019). Also, several revenue and partnership models will be needed that in turn will require new decision-making and management systems (Valdez-de-Leon, 2015, 2017; Van Alstyne et.al., 2016).

Some partners will be attracted to a revenue-sharing model, while others will instead prefer a licensing or fixed royalty-based model. Models like 'freemium' can be good to encourage experimentation and early adoption in ecosystem communities.

Another consideration here is the need to establish a revenue model that is aligned with the realities of current markets, and that is also fair to all partners involved. Likewise, to have an openness to a common drive to 'change in response to changes in the market' as put by one of the experts in our panel. This can be illustrated by the cases of Spotify, Netflix and Match Group, which have been objecting to the high commissions that Apple and Google capture as ecosystem leaders through their respective app stores.

Governance

Lastly, for an ecosystem to work well and grow, a clear set of rules is required. This means that a transparently established ecosystem governance model is needed (Cusumano and Gawer, 2002; Valdez-de-Leon, 2018; Van Alstyne et.al., 2016; Van Alstyne, 2019). An ecosystem governance model establishes very clearly the rules of engagement among ecosystem partners. It also sets out processes to deal with disputes, as well as how value will be distributed based on the agreed revenue model, as described earlier. In the end, just like all other enablers described here, the governance model needs to be defined in a way that supports the development of the ecosystem and helps create value for all stakeholders.

Use of the Framework

Practitioners may adopt the framework as a guiding tool when developing their digital ecosystem strategies, be it as an ecosystem leader, or as a participant in an existing ecosystem. The framework was structured in a way that explains the key components, yet with its primary focus being on practical application of the six enablers in forming viable platform-based companies. These six enablers can be used in different ways, depending on the context, the maturity of the ecosystem, and the strategy being pursued. The framework is not stringently prescriptive in its application, and allows for flexibility in the usage intensity of each of its enablers.

The two cases briefly described in the appendix help illustrate how the various elements in the framework, although always present, can be used in differing ways. For example, in both cases presented below, EVRYTHNG and The Things Network (TTN), a robust, modular platform was essential to the development of the ecosystems. The former began establishing market expectations by partnering with Avery, and by jointly launching a spearhead product, thus kick-starting its network effects. The latter used a pilot project in Amsterdam, and a very successful kickstarter campaign as a spearhead to a similar result. Furthermore, a comprehensive set of APIs, developer support services and robust governance models have been designed, tested, iterated and deployed, in both cases to foster developer communities, and in turn continue to

provide momentum to their ecosystem's network effects flywheel.

Other Potential Uses of the Framework

The framework is also expected to be useful as a form of checklist. When developing a digital ecosystem strategy and relevant tactical initiatives, the framework can be used as a reference to check for blind spots. Moreover, it could also be used as a reference for bench-marking ecosystems in general, whether to evaluate an ecosystem's long-term viability (how are the enablers being used?), to assess if it is worth joining an ecosystem, or as a way to compare two or more ecosystems options to participate in.

Further Research

As the framework is adopted to each ecosystem use case, it should also be further developed. The research used to construct the framework as described herein, provides an initial attempt with its own limitations in terms of magnitude and scope. The research could be expanded, both in scope and magnitude, as well as taking into account the application of other methodologies that may add a new dimension into our understanding of the various elements and enablers contained in an ecosystem.

Another clear area for further research and development of the framework relates to its applicability for the long-term development of ecosystems, including attention to the relevance of each of the framework's elements as ecosystems mature over time.

Conclusions

Much talk focuses on large digital ecosystems like those of Apple or Amazon. Yet still very little is clearly understood about their inner workings. More importantly, however, many new smaller companies emerging in current markets are interested in how organisations beyond these giants, can play with the ecosystem paradigm. The motivation behind the creation of the framework presented herein and the research behind it is to contribute to a better understanding of the concept of digital ecosystems. If ecosystems are a helpful new way of organising and enabling value creation in various markets, then it is essential that, the sooner the better, early adopting organisations and entrepreneurs understand how these ecosystems work.

The research carried out to develop this framework has been a result of ample literature review, and many years of combined experience within our expert panel members in working with digital ecosystems. We are therefore pleased to offer this framework as a comprehensive and practical guide for organisations and practitioners to deal with the transition towards digital ecosystems.

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How to Develop a Digital Ecosystem

Omar Valdez-De-Leon

About the Author

Omar Valdez-de-Leon is a digital transformation practitioner and advisor, based in Copenhagen, Denmark. Over the years Omar has worked across IT, telecom, consulting and industry in companies such as Ericsson, CGI, Honeywell and Vodafone, with a focus on new business initiatives grounded in emerging technologies. His experience in digitalisation ranges from advising utility companies on smart grid strategies to devising IoT plans for large telecom operators and smaller start-ups. He has also built, launched and managed IoT solution portfolios in utilities, transportation and FMCG. Additionally, he is member of Council, a think-tank for the internet-of-things and provides independent advisory services and lectures on digital transformation. He has written widely about digitalisation independently and for corporations, including digital ecosystems, organising for digital and more. He also developed the Digital Maturity Model as a framework to help develop digitalisation roadmaps in the telecom sector. Omar holds an MSc in Technology & Innovation Management from the University of Sussex in the UK, and an MBA from Manchester Business School.

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Appendix – Excerpts from two expert panel interviews

EVRYTHNG (EVRYTHNG)

Excerpt from an interview with Dominique Guinard, Founder and CTO of EVRYTHNG

Dominique Guinard: EVRYTHNG is a Smart Products Platform connecting consumer products to the Web and managing real-time data to drive applications. The platform enables billions of intelligent online identities in the cloud for physical products, delivers real-time interactive experiences and provides support services to consumers, connecting their digital lives in the ecosystem with other applications and products. More information on EVRYTHNG can be found on https://evrythng.com/

What has EVRYTHNG's approach been to developing their ecosystem?

Dominique Guinard: The case of EVRYTHG is an interesting one in that the company has utilised the concept of 'spearhead product' in a reverse manner, that is, as a key element to kick-starting its apparel industry ecosystem. Instead of launching a product with its own brand, it partnered with a packaging and labelling supplier of brands. As an example, Avery's Janela Connected Products platform is provided by EVRYTHNG and provides billions of products with a digital identity. More importantly, this initiative cultivates a unique ecosystem among Avery's customers, bringing brands such as Rebecca Minkoff to digitalise products such as handbags, which were not hitherto 'connected'.

Another key enabler for the EVRYTHNG ecosystem is the robust set of developer tools that focus on bringing together all kinds of technologies, standards and ecosystems in a common way. The tools include SDKs for all major device platforms and IoT protocols, connectors to virtually any cloud service, and support for any programming environment. This provides a streamlined route for developers to leverage EVRYTHNG's ecosystem. For example, it offers device manufacturers and software developers a quicker route to a NEST certification by using its own integration with the NEST cloud and making this available to its community. By saving time and providing resources for developers, this attracts developers to the platform's communities, and thus drives market expectations and network effects.

What have the results been so far?

Dominique Guinard: As of January 2018, EVRYTHNG manages about 1 Billion unique digital identities for brands such as Coca Cola, Avery, Rebecca Minkoff, Unilever, Mondelez or Diageo. Close to 10,000 developers have subscribed to the EVRYTHNG free

developer tier. EVRYTHNG has several key partnerships with packaging and labelling manufacturers such as Avery, Crown and Westrock. This accounts for billions of Consumer Packaged Goods (CPGs) and apparel products being made with digital capabilities.

The Things Network
(https://www.thethingsnetwork.org/)

Excerpt from an interview with Wienke Giezeman, Founder of The Things Network

Wienke Giezeman: The Things Network (TTN) is a distributed, user-defined IoT data network, based on LoRaWAN wireless networking technology. It aims to create an open, user-built data infrastructure for the IoT. It has more than 70,000 users globally and network nodes in 138 countries. Like the internet a few decades ago, supporters of the TTN initiative expect the IoT to grow organically, and to become decentralised in a way that enables the open exchange of data around the world.

What has The Things Network's approach been to developing their ecosystem?

Wienke Giezeman: The Things Network is a LoRaWAN platform with a reference architecture that enables users anywhere in the world to co-create the network itself. To develop such a self-organising ecosystem, TTN has relied heavily on a well-documented digital architecture, including how to build and set up the nodes as well as how to integrate the platform to user applications via its APIs.

It all started with a pilot project in Amsterdam that brought together several businesses to create a city-side network in a matter of weeks. This was followed by a very successful Kickstarter campaign to build the base equipment for TTN. These two things in turn helped attract global attention and credibility to the project.

TTN is also heavily dependent on community-building for its success. All along, users have been and are still required to install the nodes themselves in order to connect to the platform. There is no cost to join or run applications. The only contribution requirement is that nodes can be used by anyone in the community.

The community itself also provides support. A core TTN team enables community by providing communication and support channels such as github, wiki, Slack and online forums, where members rely on each other to provide support. For cases where the user might not be so technically-savvy, TTN also partners with professional services companies to provide specialised support. Finally, TTN organises events to help bring the community together and to spread the benefits of its open-source approach.

Overall, it is clear that a strong focus on community building, paired with well-documented APIs, support mechanisms and a clear governance model have been key to the rapid growth of TTN.

What have the results been so far?

Wienke Giezeman: At this moment, we have more than 70,000 members. The global network has 7,511 gateways up and running in 138 countries. Additionally, there are more than 23k applications deployed. To compare, three years ago when we presented the initiative at SXSW16 our presence was much smaller (in 100 cities with a mere 1,000 members). We have grown exponentially over the last couple of years.

Conceptualizing a New Domain Using Topic Modeling and Concept Mapping: A Case Study of Managed Security Services for Small Businesses

Michael Weiss and Steven Muegge

> *"A body of formally represented knowledge is based on a conceptualization: the objects, concepts, and other entities that are assumed to exist in some area of interest and the relationships that hold among them."*
>
> Tom Gruber,
> Co-creator of Siri

The objective of this paper is to show how topic modeling and concept mapping can be used to conduct a literature review in a new domain. The paper makes two contributions. First, it uses topic modeling to map out the literature in the new domain. Topic modeling provides an alternative to manual clustering of articles and allows the identification of non-obvious connections between ideas expressed in a collection of articles. Second, it identifies the underlying concepts in the new domain and their relationships by creating a concept map from the extracted topics . As a case study, the paper reviews the recent literature in the intersection of managed security services and small businesses. In particular, it identifies elements of the managed security services concept as it applies to small businesses. The audience of the paper includes anyone who is exploring a new domain by reviewing the literature, and in particular, students, researchers, and members of industrial R&D projects.

Introduction

Conducting a literature review in a new domain presents unique challenges, as previously noted by Weiss (2016). In existing domains, researchers can use established classifications of knowledge to guide their search for and interpretation of the literature. However, in a new domain, such classifications are not available.

There is a need for tools that can assist researchers in forming a conceptualization of a new domain in a short time frame. Gruber (1995) defines a conceptualization as the "objects, concepts, and other entities that are assumed to exist in some area of interest and the relationships that hold among them". Topic modeling (Blei et al., 2003) was developed as an alternative to manually clustering articles. It allows researchers to identify non-obvious connections between ideas expressed in a collection of articles (see, for example, the topic model created by McPhee et al. 2017 to examine the themes covered in the first ten years of the TIM Review). To add to the discourse of topic modeling, we look at concept mapping (Novak & Cañas, 2010), a tool for representing knowledge as a hierarchical structure of concepts and relationships between concepts that are created by propositions or statements.

The objective of this paper is to show how topic modeling and concept mapping can be used to conduct a literature review in a new domain. The paper makes two contributions. First, it points to topic modeling as a way to map out the literature in a new domain in terms of the underlying topics or themes. Second, it identifies key underlying concepts in the new domain, as well as charting their relationships by creating a concept map from the topic model.

To demonstrate our approach, we review the recent literature at the intersection of managed security services and small businesses, and uncovers elements of the managed security services concept as they apply to small businesses. We hope that the article will be relevant to readers of the TIM Review both for the method used to conduct the literature review, and for the content of the case study, given that security is a central concern to most small business managers as well as technology entrepreneurs.

Conceptualizing a New Domain Using Topic Modeling and Concept Mapping

Michael Weiss and Steven Muegge

The paper is organized as follows. Section 1 identifies the case study. Section 2 describes the method used to create the topic model and concept map using literature review. Section 3 presents the results of the literature review. This is followed by a discussion of the implications of the method and results for managers and researchers in Section 4. Section 5 concludes the paper.

Managed Security Services

Small businesses are as exposed to cyber attacks as their larger counterparts, but they lack the requisite expertise and resources to protect themselves. Within the general trend towards the outsourcing of computing infrastructure, it is an interesting phenomenon that businesses have also started to outsource security to managed security service providers (Gupta & Zhdanov, 2012; Cezar et al., 2017). The application of managed security services to small businesses has not yet received much attention in the literature. This paper aims to fill this gap and to identify the elements of the managed security services concept as it applies to small businesses.

A Managed Security Service (MSS) is a solution that protects the security of a business, which is difficult to implement for the businesses themselves (Zhao et al., 2013). Outsourcing the security of a business to an outside party leads to economies of scale and greater access to information (Jansen & Jeschke, 2018). A Managed Security Services Provider (MSSP) can offer its capabilities to multiple customers at the same time and is, therefore, more cost-effective than customers setting up their own internal security controls. Since an MSSP can aggregate security events from its customers and combine them with external threat intelligence, it also has access to more information that can improve its quality of service.

Method

We first identified candidate papers for the literature review from online databases such as Web of Science and Google Scholar. We then used topic modeling to detect latent themes within these articles. Topic modeling is a probabilistic technique for clustering documents that does not require a human to label the documents. A common topic modeling technique is Latent Dirichlet Allocation (LDA) (Blei et al., 2003). Given a corpus of documents and a number of topics, LDA produces a probability distribution that indicates the topics each document is about, as well as a probability distribution of keywords associated with each topic.

To construct the topic model, we used only paper abstracts as documents, rather than full articles. By focusing on the abstracts, we emphasize highlights of the articles as summarized by its authors. We also recommend using abstracts if the documents in the corpus vary in length. In the example of the literature on MSSs, the corpus includes papers, white papers, and theses of widely different length. . We first created topic models of different sizes, and increased the number of topics until stable topics emerge that are common among the topic models generated [the number cannot become stable as it steadily increases, only the topics, which, beyond some number of topics, tend to recur in the topic models generated]. We then sorted those [no processing on topics] topics by weight (based on the number of documents that have each topic as their first) and only included the top 90%, thus serving to eliminate topics that lack support in the corpus (Mathew et al., 2017).

To interpret the topics, we first used agglomerative clustering to identify the main topics and subtopics (Quinn et al., 2010). We then manually created a concept map from the topic keywords. This concept map presents groups of related keywords and graphically shows salient relationships between keywords. Constructing the map was an iterative process, during which time the key concepts related to the new domain were identified. Finally, alongside of the concept map, we plotted the number of articles published per year and the distribution of topics within each year to understand how the new domain is emerging and taking shape.

Results

Corpus of Articles

We first searched the Web of Science database for articles on “managed security services”. Since this search only returned 22 articles, we complemented this corpus with articles from the “grey” literature. By searching Google Scholar for articles that match the query “managed security services” AND “small companies” OR “sme”, we identified 67 additional articles that included conference papers, theses, and reports, but excluded patents, white papers (with the exception of market surveys), magazine articles, and books. Table 1 shows the composition of the corpus of articles.

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Table 1. Description of the corpus

Database	*Web of Science*	*Google Scholar*	*Total*
Count	22	67	89
Date Range			
Oldest article	2003	2001	2001
Newest article	2018	2019	2019
Type			
Journal article	13	25	38
Conference paper	9	10	19
Thesis	0	28	28
Report	0	3	3
Book section	0	1	1

Table 2. Topics and their associated keywords, sorted by weight.

Topic	Keywords
1	security, services, managed, network, risks, detection, cloud, outsourcing, infrastructure, outsourced
4	business, software, management, firms, monitoring, mss, companies, operation, competition, intrusion
2	open, computing, test, positive, tool, adoption, multi, dynamic, light, provided
6	system, manage, ensure, sites, complex, transition, novel, attacks, analysts, operations
8	tool, private, traffic, proactive, scan, iaas, vpm, infected, hosts, clouds
10	critical, areas, source, trusted, program, organization, production, house, interaction, verisign
3	mssp, large, risk, independency, practices, growth, investment, externalities, caused, industry
5	detection, intrusion, threat, potential, enterprise, rate, scan, real, defender, leverage, optimal, tools
7	project, process, aspects, platform, measures, configuration, team, organizational, industrial, training
9	worm, traffic, networks, requirement, presented, clients, rate, scan, managing, hosts

Conceptualizing a New Domain Using Topic Modeling and Concept Mapping

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Topic Modeling

To determine the best right number of topics, we iterated the topic model with different numbers of topics, until a set of mostly independent clusters of documents emerged. The literature also suggests that 10-12 topics are a good heuristic value (Mathew et al., 2017). We found 10 topics to be a good fit for our corpus. At this point, several stable topics had emerged, with little overlap between keywords across topics. After sorting the topics by support in the corpus, three topics were eliminated by applying the 90% cut-off. Table 2 shows the topics and their associated keywords.

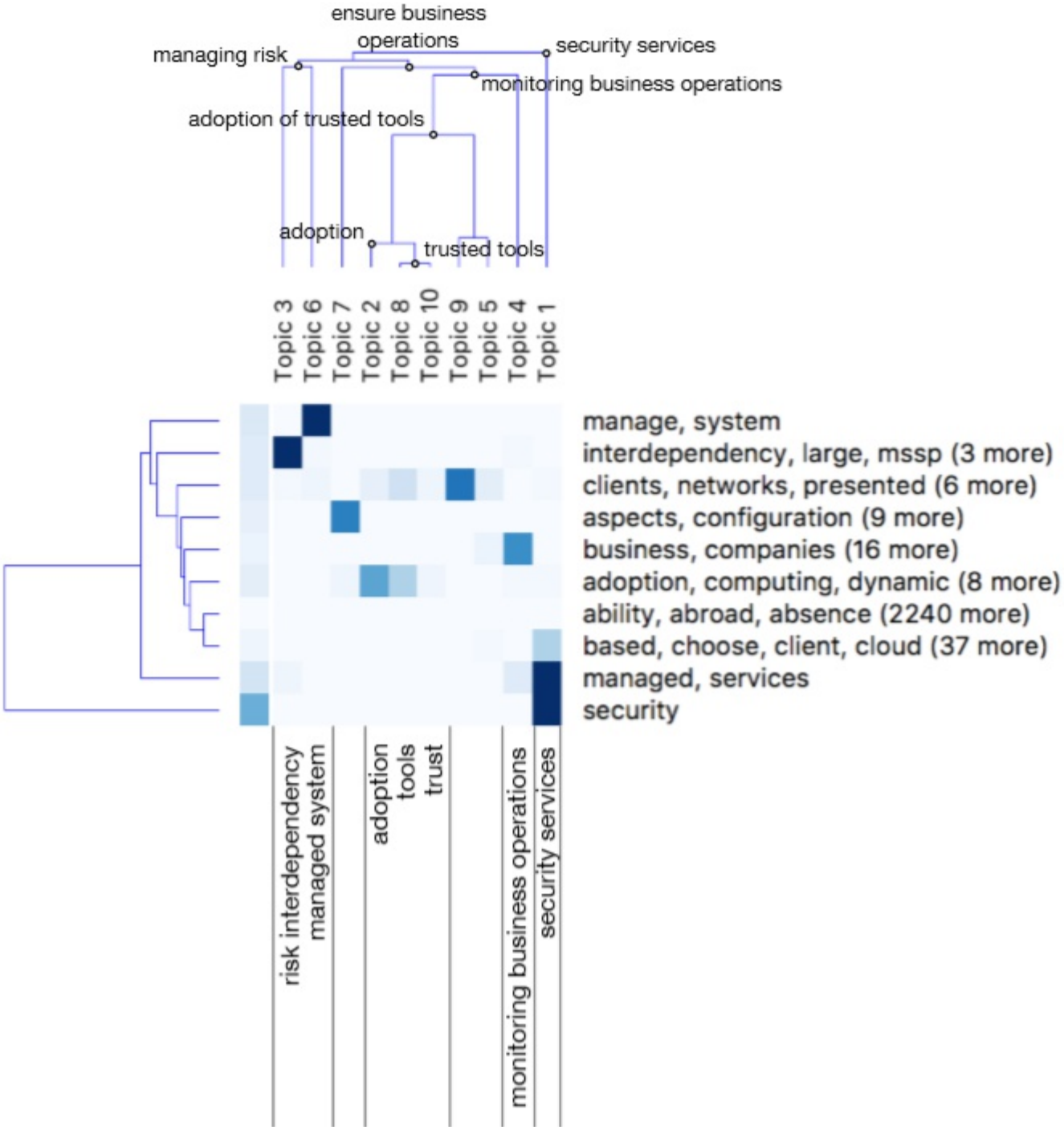

Figure 1. Clustering the topics into main topics and subtopics.

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Clustering the Topics

The topics were clustered by merging two topics (which then become subtopics of a new topic that is produced as the result of clustering) at a time that are similar and proceeding recursively in this manner, until only a single topic remains. (Topics eliminated during the previous step were included in the clustering process and then merged with the most closely related topic.) The dendrogram produced by clustering is shown in Figure 1. The lower the height at which two topics or groups of topics are connected, the more similar they are (Quinn et al., 2010). Labels were assigned to nodes in the dendrogram by examining keywords in the connected topics.

From this analysis of the MSS for small businesses domain, three top-level topics emerged: the security services that a small business adopts, ensuring the operations of the small business, and managing risk. The second topic can be subdivided into four topics: monitoring business operations, adoption of managed security services, tools, and trust. The third topic (managing risk) comprises two subtopics: risk from interdependency, and a managed system.

Emerging Topics over Time

Plotting the topics over time shows an overall increase in interest in the topic of managed security services, as shown in Figure 2. However, we can identify two waves of publications. The first wave peaks in 2009, the second wave in 2015. The three most popular topics in 2009, according to the articles included in our sample, were security services, monitoring business operations, and a managed system. In 2015, they were security services, adoption of security services, and risk from interdependency. From 2009 to 2015, a noticeable shift in focus occurs from operations and systems to reasons for adoption and risk considerations.

Concept Mapping

We created a concept map to identify the elements of the MSS concept as it applies to small businesses. We grouped the topic keywords into concepts to construct the concept map in Figure 3. For example, topic 1 contains the concepts MSS and outsourcing, and topic 4 includes the concepts business, managing operations, monitoring, and intrusion detection. Each concept in the concept map is represented by its own cluster of keywords related to the concept.

We labeled the clusters in the concept map: business, MSS, managed system, intrusion detection, outsourcing, managing operations, and risk from interdependency. We established links between concepts when they were either part of the same topic (e.g. MSS and outsourcing), or semantically related (e.g. “hosts” in the managed system concept and “infected” in the intrusion detection concept are related terms: as in a host that is infected by an intrusion).

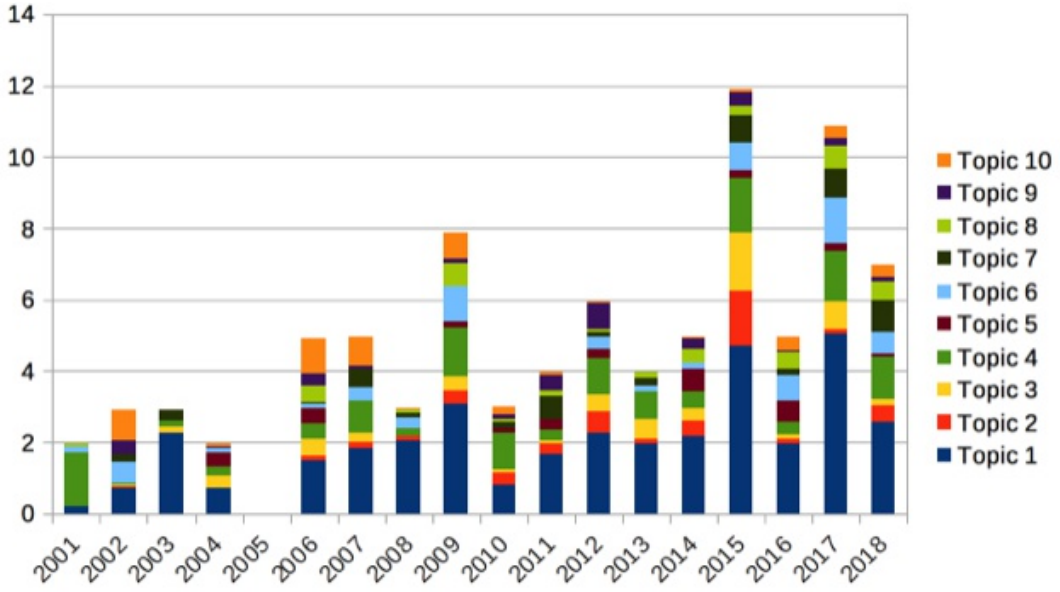

Figure 2. Emergence of the topics over time.

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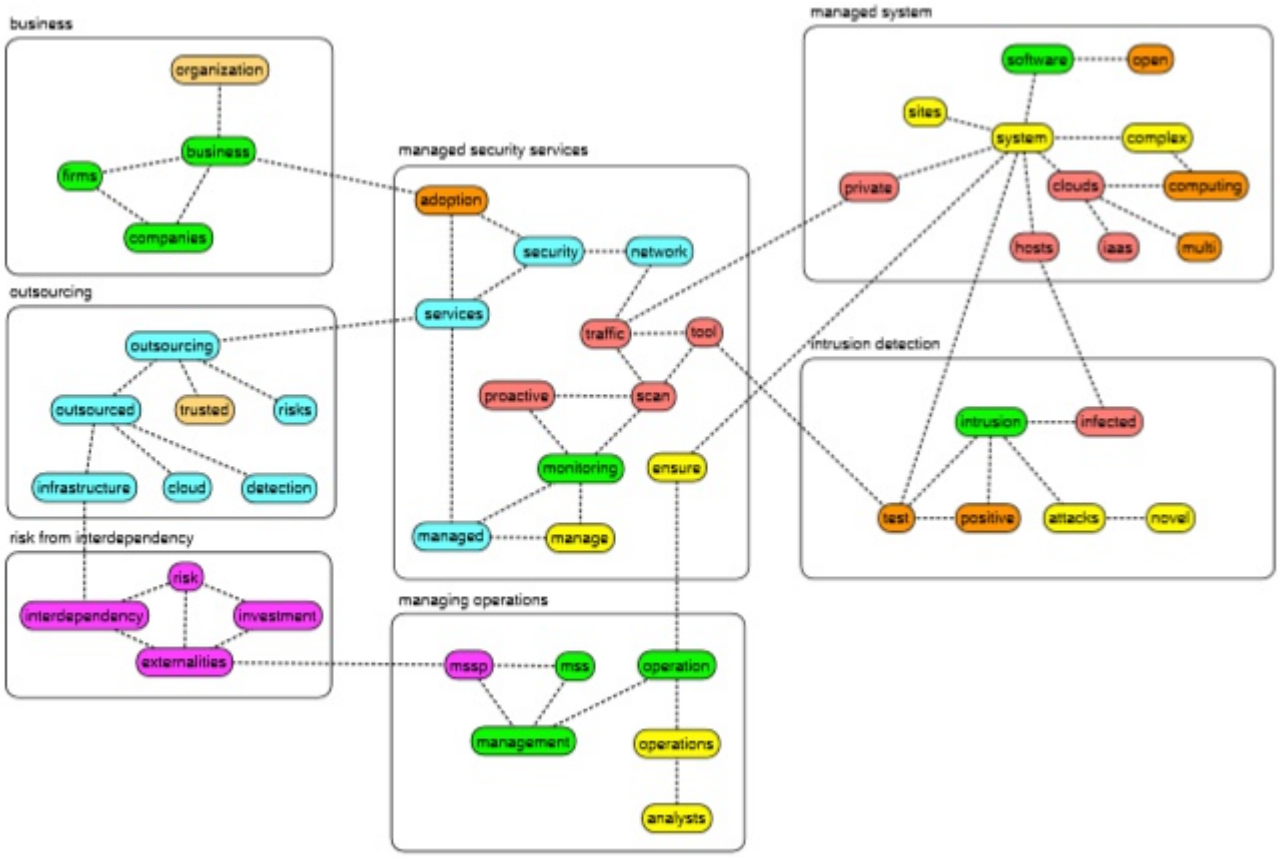

Figure 3. Concept map for the elements of the managed security services concept

Note that, in Figure 3 below, links between concepts are not labelled. Rather, concept maps as described by Novak and Cañas (2010) connect the concepts through propositions. These propositions cannot be obtained from the topic model directly, but it is possible to extract them from a close analysis of specific sentences in documents in the corpus that contain those concepts. It is worth adding that existing work on "ontology learning" (Wohlgenannt et al., 2012) also appears promising as a way to help automatically extract links between concepts.

Discussion

For managers, this paper highlights a crucial shift from operations to risk considerations when small businesses outsource their security . The early literature, focused almost exclusively on the benefits of outsourcing security, such as reduced cost and increased quality, for example, Broom (2009). Whereas recent literature takes a more systemic perspective in which businesses and MSSPs should be considered as agents in a complex system of interdependencies, as noted by Cezar et al. (2017).

The implications for researchers are twofold. The paper shows that topic modeling is a promising approach to review literature in a new research area, and [this introduces a new idea that goes beyond topic modeling] proposes a technique for interpreting topics that involves constructing a concept map from the keywords. Previously, the interpretation of extracted topics has relied mostly on generalizing from the keywords associated with each topic. Combining concept maps with topic models provides greater visibility into the context in which the keywords associated with the topics are embedded.

Conclusion

This paper shows how a new domain like that of MSS for small businesses can be studied to discover new insights by combining topic modeling with concept mapping. Topic modeling enables researchers to identify latent

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topics from the literature related to a new domain and to study how these topics have emerged over time. By creating a concept map from the topics and their associated keywords, researchers can identify a set of concepts in the new domain along with their relationships.

This paper's novel contribution is to identify and begin to articulate the process of creating a concept map from a topic model. Currently, the process has to be performed manually. However, we believe that creating concept maps from a topic model can be, at least partially, automated, and therefore suggest that future research efforts be directed towards that goal.

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About the Authors

Michael Weiss holds a faculty appointment in the Department of Systems and Computer Engineering at Carleton University, and is a member of the Technology Innovation Management program. His research interests include open source ecosystems, mashups/Web 2.0, business process modeling, social network analysis, and product architecture and design. Michael has published on the evolution of open source communities, licensing of open services, and innovation in the mashup ecosystem.

Steven Muegge is an Associate Professor of Entrepreneurship at Carleton University in Ottawa, Canada. Dr. Muegge leads an active research program in technology entrepreneurship within the Technology Innovation Management (TIM) program. His research, teaching, and community service interests include platforms, communities, and business ecosystems, and the business models of technology entrepreneurs, especially in early-stage product-market spaces. Dr. Muegge holds a Bachelor of Engineering degree in Engineering Physics from McMaster University, a Master of Engineering degree in Telecommunications Technology Management from Carleton University, and a Ph.D. in Management from Carleton University.

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