Asset Analytics
Performance and Safety Management
Series Editors: Ajit Kumar Verma · P. K. Kapur · Uday Kumar

Sarbjeet Singh
Alberto Martinetti
Arnab Majumdar
Leo A. M. van Dongen *Editors*

Transportation Systems

Managing Performance through Advanced Maintenance Engineering

Springer

Chapter 9
Innovation Management in Outsourced Railway Maintenance: The Case of a Dutch Railway Service Provider

S. K. Wu, A. J. J. Braaksma and Leo A. M. van Dongen

Abstract Despite a complex, fragmented and from origin conservative environment, railway service provider organizations in the Dutch railways are innovating at a high pace. Therefore, the Dutch railway sector is a rich environment for studying innovations. To understand how this is achieved, an innovation management framework is developed and used to analyze innovation factors in this context. Based on a literature review on conceptual frameworks for innovation management of the last five years, a holistic innovation management framework is constructed, using an inductive coding methodology. The holistic innovation management framework is used to analyze the case study organization, based on interviews and desk research. The analysis indicates that various market, organization, process, and product/service factors and their interaction contribute to a high pace of innovations. The coding methodology used in this study can be influenced by researcher's bias. In addition, the selected documentation received from the case study may not be representative for the case study organization. The presented research shows that the Dutch railway sector is a sector which deserves further research to learn from their innovative maintenance practices on a more detailed process level. In addition, the presented framework is a step towards a holistic innovation management framework which can be used to analyze innovations on a sectoral level. The research results give practitioners insights on how to develop innovation management practices in the railway sector. This research presents an in-depth analysis on the innovation management practices that have been applied in the successful Dutch railway sector from the perspective of a railway service provider.

S. K. Wu (✉) · A. J. J. Braaksma · L. A. M. van Dongen
Maintenance Engineering Group, University of Twente, Enschede, The Netherlands
e-mail: s.k.wu@utwente.nl

A. J. J. Braaksma
e-mail: a.j.j.braaksma@utwente.nl

L. A. M. van Dongen
e-mail: l.a.m.vandongen@utwente.nl

L. A. M. van Dongen
Netherlands Railways, Utrecht, The Netherlands

S. Singh et al. (eds.), *Transportation Systems*, Asset Analytics,
https://doi.org/10.1007/978-981-32-9323-6_9

Keywords Railways · Innovations · Innovation management · Processes

9.1 Introduction

Internal and external forces push railway organizations to accelerate their rate of innovation. However, issues such as conflicting goals, directed at either short or long-term; challenging coordination, in relation to data and resources; and the ability to measure results, with regards to innovations, all contribute in the complexity of effective innovation management. Despite these challenges, Dutch railway organizations are innovating at a high pace. To understand how these organizations achieve this performance, this research sets out to identify the factors that enable the high pace of innovation.

"While innovation is on the agenda of almost all organizations, successful innovation management remains quite elusive for many managers" (Erzurumlu 2017, p. 42). This chapter provides an overview of the latest state of innovation studies, which have been combined into a holistic innovation management framework. Using the holistic innovation management framework, a case study is performed on an innovative Dutch railway service provider, to identify the factors that contribute to the high pace of innovations.

This chapter is structured in the following way. The following section introduces the research methodology. The third section of this chapter discusses the different levels of innovation and decision-making that is found in literature. The fourth section presents the case study of an innovative organization in the Dutch railways, being a privately owned railway service provider. Section five discusses the findings of this chapter. Finally, section six concludes this chapter with a summary, limitations of the study, and implications for practitioners and researchers.

9.2 Research Methodology

To identify the factors that enable the high pace of innovation, a holistic innovation management framework is developed (see Fig. 9.1: Conceptual innovation framework). Consequently, the innovation management framework is applied to the case study organization to identify the specific factors that enable the high pace of innovation. Data is collected via semi-structured interviews and are validated through documentation, the internal organizational website, and external websites.

The developed innovation framework is based on a literature review. A search is performed on Web of Science and Scopus with the keywords "innovation" AND "conceptual framework" between 2013 and 2018. A total of 48 articles are found on Web of Science and 62 on Scopus. Only peer-reviewed articles are selected for the literature review, resulting in 26 articles on Web of Science and 43 articles on Scopus. 21 articles appeared in both search platforms, resulting in 48 articles that

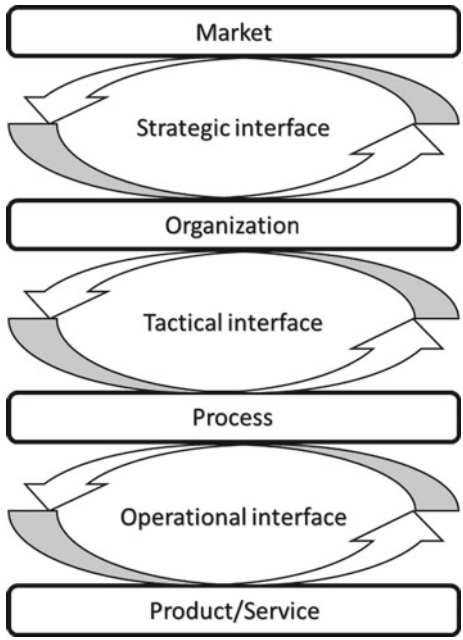

Fig. 9.1 Conceptual innovation framework

fulfilled the search criteria. One article is only available in Spanish, leaving the total selection of reviewed articles to 47 (see Table 9.1: Overview of reviewed articles)

An inductive coding method is applied to the selected literature (Evens 2013). Since studies in innovation management are approached from different perspectives and lack a holistic overview, this method is appropriate (e.g., Bélanger et al. 2016; Berkowitz 2018; Periac et al. 2018). Four stages of coding are performed. The first stage involves reading the abstracts of the selected articles and making analytical memos, which are organized in an excel file, to keep an overview of the data (Saldaña 2015). One article, which was published in a medical journal, did not have an abstract, therefore, its content was read. In the second stage, the actual coding takes place. Different categories, with regards to innovation, are identified in the second stage per article, based on the content of the articles. A word and/or noun is connected to each article, after each article is carefully read, to summarize the basic topic of an article, also known as descriptive coding (Saldaña 2015). In the third stage of coding, focused coding is applied (Saldaña 2015). Focused coding searches for the most significant codes, by categorizing similar themes together (Saldaña 2015). Finally, codeweaving is applied in the fourth stage. Codeweaving is the integration of codes into a narrative form. In particular, the interrelations between the categories are used, which results in the holistic conceptual innovation framework (Saldaña 2015, see Fig. 9.1 and Table 9.1). In addition, all articles are categorized according to the conceptual framework in stage four, based on their content, since most articles contain several categories rather than a single one. In the following section, the theoretical background of the conceptual innovation framework is presented.

Table 9.1 Overview of reviewed articles

#	Year	Authors	Coding stage 1	Coding stage 2	Coding stage 3	Coding stage 4
1	2018	Periac, F. et al.	Micro-quality of life improvement and macro-quality of life sustainment	Society	Society	Market
2	2017	Berkowitz, H.	Organizing capabilities at the firm level	Capabilities	Resources	Organization
3	2018	Rodriguez, L. and Da Cunha, C.	Knowledge exchange in the supply chain	Supply chain	Partners	Market
4	2017	Grubb, M. et al.	Policy mixes in different domains	Socio-economic	Society	Market
5	2017	Liu, S. et al.	Upstream and downstream innovations	Supply chain	Partners	Market
6	2017	Troilo, G. et al.	Integrates service innovation with information systems literature	Service	Development	Product/service; operational interface; market
7	2017	Binz, C. and Truffer, B.	Multi-scalar innovation systems	Innovation dynamics	Customer	Operational interface; market
8	2017	Dubina, I.N. et al.	Entrepreneurial ecosystem	Network	Partners	Market
9	2017	Mansour, D. and Barandas, H.	Capturing customer value	Customer value	Customer	Market
10	2017	Botschen, G. and Wegerer, P.K.	Brand identity development	Branding	Marketing	Strategic interface
11	2017	Caiazza, R.	Classifies knowledge transfers	Knowledge types	Resources	Organization

(continued)

Table 9.1 (continued)

#	Year	Authors	Coding stage 1	Coding stage 2	Coding stage 3	Coding stage 4
12	2016	De Waal, G.A.	Extends the Ansoff product-market expansion grid, based on developed world and emerging markets	Market strategy	Strategy	Strategic interface
13	2016	Caputo, A. et al.	Product innovation types	Innovation types	Products	Product/service
14	2015	Gaziulusoy, A.I. and Brezet, H.	Integrates sustainability science, system innovations, and transition theories	System innovations	System	Product/service; strategic interface
15	2015	Malik, K. and Bergfeld, M.M.	Intra-company technology transfer	Technology transfer	Resources	Operational interface; organization
16	2015	EL-Griffin, E. W.	Integrates social capital with network theory	Network	Partners	Market
17	2015	Morrar, R.	Public-Private innovation networks interaction	Collaborative development	Partners	Operational interface; market
18	2015	Tang, M. et al.	Innovation system	Network	Partners	Market
19	2015	Lee, I.	IoT and supply chain	Supply chain	Partners	Market
20	2015	Nguyen, H.	Imitation literature	Innovation imitation	Strategy	Product/service; operational interface; organization; market

(continued)

Table 9.1 (continued)

#	Year	Authors	Coding stage 1	Coding stage 2	Coding stage 3	Coding stage 4
21	2015	Christofi, M. et al.	Application of innovation theory on cause-related marketing	Marketing	Marketing	Strategic interface
22	2015	Zhang, T. et al.	Online co-innovation communities applied in the hospitality industry	Co-innovation	Partners	Operational interface; process; market
23	2014	Cajaiba-Santana, G.	Combines institutional and structuration theories.	Societal	Customer	Market
24	2014	Kumar, V.	Integrates cultural with innovation literature	Cultural	Customer	Market
25	2014	Shao, L. et al.	Applies Business model innovation on Electric vehicles in Shenzhen city, China	Business model	Functions	Organization
26	2014	Coutelle-Brillet, P. et al.	Combines perceived value with service innovation adoption	Service value	Customer	Product/service; market
27	2018	Rinkinen, S. and Harmaakorpi, V.	Ecosystem approach to service valuation	Customer valuation	Customer	Operational interface; market
28	2017	Tariq, A. et al.	Drivers, moderators, and consequences of green products and processes	Market factors	Market	Market

(continued)

Table 9.1 (continued)

#	Year	Authors	Coding stage 1	Coding stage 2	Coding stage 3	Coding stage 4
29	2017	Barth, H. et al.	Business model innovation	Business model	Functions	Organization
30	2017	Erzurumlu, S.S.	Innovation management evaluation	Innovation evaluation	Development	Operational interface
31	2017	Hashmi, A. et al.	Input-process-output model and transformational leadership theory	Team work	Organizing	Tactical interface
32	2017	Lager, T.	process-industrial production and innovation characteristics	Industry sector	Customer	Market
33	2017	Bedoya Villa M.A. and Arango Alzate B.	N/A	N/A	N/A	N/A
34	2016	Takey, S.M. and Carvalho, M.M.	Fuzzy front end and systemic innovation	Idea generation	Process	Operational interface; process
35	2016	Buliga, O. et al.	Business model innovation, organizational resilience, regulatory focus theory	Organizational change	Organizing	Operational interface; process; organization
36	2016	Widya Hastuti, A. et al.	Process innovation, intrapreneurship, and sustainable innovation	Process innovation	Organizing	Product/service; tactical interface

(continued)

Table 9.1 (continued)

#	Year	Authors	Coding stage 1	Coding stage 2	Coding stage 3	Coding stage 4
37	2016	Mulyaningsih, H.D. et al.	Entrepreneurship, social innovation and knowledge management	Innovation types	Product/Service	Product/service; operational interface; process
38	2016	Bélanger, S. et al.	Creativity and innovation	Creativity	Development	Operational interface; process; tactical interface
39	2016	Maier, M.A. et al.	Innovation stakeholders	Stakeholders	Partners	Market
40	2015	Sindakis, S.	Corporate entrepreneur-ship and new service development	Development processes	Organizing	Tactical interface
41	2015	Arshad, A.M. and Su, Q.	Service delivery and service quality	Customer service	Customer	Tactical interface; market
42	2015	Chernoivanova, A.S.	Functions of business management and innovation	Innovation functions	Development	Operational interface; process
43	2015	Overall, J.	Social capital, the resource-based view of the firm, and relationship quality	Innovation performance	Evaluation	Operational interface; tactical interface
44	2014	Weisberg, R.W. et al.	Employee involvement in the healthcare sector	Service development	Development	Operational interface; tactical interface
45	2014	Somers, S. and Stapleton, L.	E-agricultural adoption and innovation	Community	Customer	Market
46	2014	Maritz, A. et al.	Innovation education	Education	Institution	Market

(continued)

Table 9.1 (continued)

#	Year	Authors	Coding stage 1	Coding stage 2	Coding stage 3	Coding stage 4
47	2014	Christofi, M. et al.	Cause-related marketing and corporate social responsibility	Marketing	Marketing	Strategic interface
48	2014	Kuzmin, O.I. and Grom, O.B.	Knowledge economy and networking dissemination	Knowledge	Development	Operational interface

9.3 Theoretical Background

The conceptual framework distinguishes between the objects of innovation studies and decision-making interfaces. In order to achieve effective innovation management, alignment between the three layers of decision-making is required. The objects of innovation management consist of the market, the organization, the process, and the product/service. The interfaces between the different objects consist of strategic, tactical, and operational decision-making interfaces. Each object has characteristics, which can influence the decision-making in relation to a higher level object or a lower level object. To present the framework in a comprehensive manner, the lowest level will be explained first, namely the product/service.

9.3.1 Product/Service

A product or service has the purpose of providing value to its user (Coutelle-Brillet et al. 2014; Mansour and Barandas 2017; Rinkinen and Harmaakorpi 2018). The development of new products and services can have different levels of impact on existing products and services. To identify an innovation, a description of the product or service that provides value is required. In this paragraph, the different types of product innovations and the difference between a product and service are discussed.

9.3.1.1 Product Types

During its lifecycle, product transitions through different levels of innovativeness (Fig. 9.2: The dual axis model of Henderson and Clark). The dual axis model aims to model the level of innovativeness via two dimensions, namely the level of impact on a component and the level of impact on the architecture of the new product (Caputo et al. 2016). Resulting in four types of innovations: (1) radical innovations have a

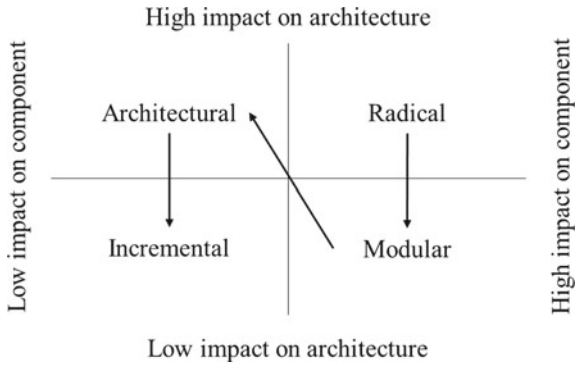

Fig. 9.2 The dual axis model of Henderson and Clark (1990). Adapted from Caputo et al. 2016

high impact on a component, as well as the architecture; (2) modular innovations will have a low impact on the architecture, but will have a high impact on a component; (3) architectural innovations will have a high impact on the architecture, but a low impact on a component; finally, (4) Incremental innovations have a low impact on the architecture, as well as a low impact on the component (Caputo et al. 2016; Coutelle-Brillet et al. 2014; Gaziulusoy and Brezet 2015; Phuc 2015).

Radical innovations are new to the world and cause a paradigm shift in the way value is perceived in a market (Caputo et al. 2016; Coutelle-Brillet et al. 2014; Gaziulusoy and Brezet 2015; Mulyaningsih et al. 2016; Phuc 2015). Modular innovations are already on the market, but new to the company and can be viewed as additions or replacements of specific products (Caputo et al. 2016; Coutelle-Brillet et al. 2014; Gaziulusoy and Brezet 2015). Architectural innovations are innovations that already exist but are adapted for a new market to fit the processes of that market (Caputo et al. 2016; Coutelle-Brillet et al. 2014; Gaziulusoy and Brezet 2015). Incremental innovations are adaptations or modifications to existing products to better fit the context of the organization (Caputo et al. 2016; Coutelle-Brillet et al. 2014; Gaziulusoy and Brezet 2015; Hastuti et al. 2016; Phuc 2015).

9.3.1.2 Service

A product or service is developed and implemented with the purpose of creating value for its user. Contrary to a product, a service is intangible, is often co-produced with the user, is simultaneously produced and consumed, is heterogeneous, and perishes the moment the exchange ends (Troilo et al. 2017). An organization can be perceived as a system, where different roles and assets perform activities (modules) and are connected via a process (architecture) to produce a service or a collection of services. Applying the four types of innovations on the organization, results in: (1) radical innovations having a high impact on the activities and processes of the organization, (2) modular innovations having a high impact on certain activities in the organization and a low impact on the processes, (3) architectural innovations

having a low impact on the activities and a high impact on the processes, and (4) incremental innovations having a low impact on the activities and processes.

To develop and produce products and services, an operational interface is required. This is generally organized via different categories of activities in an organization. In the following paragraph, the operational interface is discussed.

9.3.2 Operational Interface: Developing Products/Services

The operational interface develops and produces products and services. Depending on the type of innovation, the effort required to develop and produce an innovation will be different. To illustrate, buying a module off-the-shelf will require less effort than developing a fundamentally new product or service. In general, organizational activities are separated in different organizational components, which are responsible for performing activities to develop and produce products and services. In theory, these organizational components interact via project teams. However, for illustration purposes, the activities are categorized. In this paragraph, the following four categories of activities should be present in the development and documentation of a product/service: market research, development, sponsor, and documentation.

9.3.2.1 Market Research

The purpose of an innovation is to solve a problem, therefore a clear description of the problem and the owner of the problem or targeted user is required (Bélanger et al. 2016; Mulyaningsih et al. 2016). To indicate the market potential, an estimation of the size of the problem and a description of the process for making the estimation should be documented (Takey and Carvalho 2016). The market potential provides an input for the size of the investment, that is realistic for solving the problem (Takey and Carvalho 2016). A market research should be performed to investigate existing solutions (Bélanger et al. 2016). If existing solutions do not fit the problem which the organization faces, new ideas can be generated in creative sessions (Zhang et al. 2015). Prior to development, a business feasibility study should be performed, containing a description of the new/improved product/service, its intended user, and required organizational resources (Takey and Carvalho 2016).

9.3.2.2 Development

To indicate a direction for the development of the solutions, principles, and criteria for the solution must be stated (Kuzmin and Grom 2014). It is advisable to include users and employees in this process to gain support for innovation (Weisberg et al. 2014). If the selection of a realistic solution is not straightforward, voting by the participants and/or a jury consisting of managerial members can lead to a final selection (Zhang

et al. 2015). During the development of the selected solutions, experiments and tests may be required. To further gain support from employees, these experiments and tests should also include a user or customer of the product/process (Bélanger et al. 2016; Buliga et al. 2016; Zhang et al. 2015). Prior to implementation, several iterations may be required to ensure fulfilment of the criteria of the solution, as stated prior to selection (Bélanger et al. 2016; Kuzmin and Grom 2014).

9.3.2.3 Innovation Sponsoring

The sponsor is responsible for the investment of organizational resources and the return on investment. In case collaborators invest organizational resources in the innovation effort, these should be communicated to the sponsor (Erzurumlu 2017; Rinkinen and Harmaakorpi 2018; Troilo et al. 2017). An estimation of investments in capabilities and assets of the partners or institutions in the innovation effort, as well as the division of potential profit and intellectual property, should be indicated if applicable (Morrar 2015; Mulyaningsih et al. 2016; Takey and Carvalho 2016). During the development process, the sponsor approves or terminates the innovation effort (Malik and Bergfeld 2015). Prior to commercialization, the sponsor should review the development to decide whether a product/service is still beneficial for the organization in its current state. Approval of the sponsor is required, otherwise, a product/service should be terminated (Buliga et al. 2016).

9.3.2.4 Knowledge Management

Knowledge management plays an important role in product/service development (Bélanger et al. 2016; Overall 2015). The different activities in product/service development should result in documentation to enable knowledge transfer. General information enables efficient retrieval of documentation and should indicate the date of writing, authors of the document and contact information, indication of confidentiality, version number, and sponsor of the innovation effort (Malik and Bergfeld 2015). To communicate the problem context, an introduction should include a description of the context, such as the market, industry, organizational resources, and the resources of partners relevant for the innovation effort (Erzurumlu 2017; Rinkinen and Harmaakorpi 2018; Troilo et al. 2017). A description of the alternative solution, selection method, and outcomes of the innovation effort should be documented and updated (Chernoivanova 2015; Takey and Carvalho 2016). Unforeseen challenges and problems should be documented to enable learning for future innovation processes (Binz and Truffer 2017; Malik and Bergfeld 2015; Phuc 2015).

The operational interface can be managed via an integrated innovation process, to coordinate resources and information, which will be presented next. The process for innovations is defined as a collection of activities over time to explore and exploit new products and services.

9.3.3 Process

The process for innovations is defined as a collection of activities over time to explore and exploit new products and services. The exploration stage of the innovation process is focused on the development of new or improved products and services (Buliga et al. 2016). The exploitation stage of the innovation process is focused on implementing or selling the products and services to the users or customer, respectively (Bélanger et al. 2016; Buliga et al. 2016).

9.3.3.1 Exploration Stage

The main purpose of the exploration stage is the selection and development of ideas according to the strategy of an organization (Chernoivanova 2015). The exploration stage can be divided into different process steps and includes managerial decision-making prior to transitioning to the next step (Bélanger et al. 2016; Mulyaningsih et al. 2016; Takey and Carvalho 2016). Each of the four types of innovation (radical, modular, architectural, and incremental) are suitable for the exploration stage of the innovation process. Presence of the following steps allows a structured process with regards to innovations:

- *Opportunity identification* involves the discovery of a problem in the market or organization (Bélanger et al. 2016; Mulyaningsih et al. 2016). Opportunity analysis provides an indication of the scale of the problem (Takey and Carvalho 2016).
- *Idea generation and enrichment* aim at generating and further developing ideas which may solve the problem (Bélanger et al. 2016; Mulyaningsih et al. 2016; Takey and Carvalho 2016; Zhang et al. 2015).
- *Idea selection* involves selecting the most promising ideas that align with the strategy of the organization (Chernoivanova 2015; Takey and Carvalho 2016).
- *The concept definition* process step presents a product/service and its costs and benefits for a specific user (Takey and Carvalho 2016).
- *Business feasibility* identifies the gap between required capabilities and assets and current capabilities and assets and determines whether the product/service concept is feasible (Mulyaningsih et al. 2016; Takey and Carvalho 2016).
- *Organizing capabilities and assets* for product/service development involve experiments to gain new knowledge and testing variations of applications of the concept in real life situations (Bélanger et al. 2016; Buliga et al. 2016) (Fig. 9.3).

9.3.3.2 Exploitation Stage

The main purpose of the exploitation stage is to increase adoption of the innovation. During the exploration stage investments in capabilities and assets lead to a product/service. In the exploitation stage, these investments can be earned back with

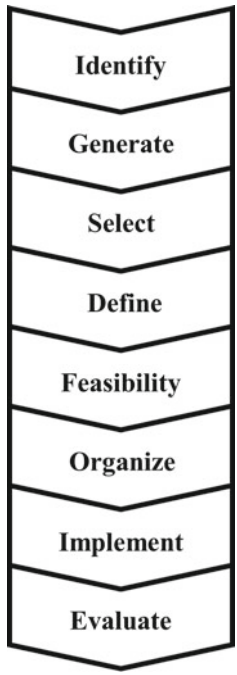

Fig. 9.3 Innovation process

the potential of creating a profit for the organization. To do so, the number of users and/or customers of the developed innovation should fulfill their market potential. The last two steps of the innovation process are:

- *Implementation* is the process step where the product/service becomes useful for a user (Bélanger et al. 2016).
- *Evaluation* of the benefits and costs as indicated in the concept definition is reviewed leading to termination, iteration or the exploitation of the product/service (Buliga et al. 2016).

In theory, the last two process steps of the innovation process should apply for every new user or customer of the innovation. Therefore, attention should be paid to new users and customers for implementing and evaluating the innovation in their specific context. The earlier the user or customer is involved in the innovation process, the more likely the adoption of the innovation will be (Bélanger et al. 2016; Buliga et al. 2016; Zhang et al. 2015).

To standardize and adapt the process according to organizational needs, the tactical interface is required. The tactical interface involves general management and innovation management capabilities, which will be discussed in the next paragraph.

9.3.4 Tactical Interface: Organizing the Innovation Process

The tactical interface concerns acquiring and developing skills that are needed to standardize and adapt business processes to fit organizational and market needs. Standardizing business processes involves general management, while adapting business processes involves innovation management (Arshad and Su 2015; Bélanger et al. 2016). In general, innovation management precedes general management since a product/service must first be developed in order for it to be managed in a standardized way. However, adapting processes to fit organizational needs better after standardization is not uncommon in practice. In this paragraph, the management types are described as two extremes, while in practice more nuance is present.

9.3.4.1 General Management

General management enables the standardization of processes. Activities of general managers include planning, organization, motivation, control, and regulation (Arshad and Su 2015; Bélanger et al. 2016). Planning is a mechanism that enables control by creating transparency in the process, through the use of target milestones and measurable goals over time (Bélanger et al. 2016). Organization is the ability to organize the required knowledge to fulfil activities to achieve target milestones and measurable goals (Bélanger et al. 2016). Motivation can be achieved by means of transformational or transactional leadership styles (Hashmi et al. 2017; Overall 2015). Control involves the monitoring of the progress in relation to the strategic objectives, as well as the performance of activities (Overall 2015). A too aggressive approach to control can have a negative effect on creativity (Bélanger et al. 2016). Finally, regulation involves the ability to influence the progress and performance by means of additional capabilities and assets and is strongly connected to control (Overall 2015).

9.3.4.2 Innovation Management

Innovation management facilitates processes to fit organizational needs. Innovation management requires two main skills in order to be successful, namely employee involvement and supporting intrapreneurship. The first skill requires employee involvement in the formation of new business opportunities by means of, for example, idea platforms or innovation tournaments (Arshad and Su 2015). By involving employees in the innovation process, the support for adopting a new service/product becomes higher and a culture of innovation can be stimulated (Arshad and Su 2015; Weisberg et al. 2014).

The second skill involves supporting intrapreneurship (Hastuti et al. 2016; Sindakis 2015). An intrapreneur is an entrepreneurial individual inside an organization, who is pro-active, takes risks, and is autonomous (Hastuti et al. 2016). The benefit of

an intrapreneur is the speed at which innovations can be developed and implemented relative to formal business processes. The intrapreneur shares commonalities with the project manager, however, the intrapreneur is more autonomous in selecting ideas to develop and/or implement (Arshad and Su 2015). To manage the intrapreneur three considerations should be kept in mind (Sindakis 2015):

(1) The outcomes of innovations should be measured and evaluated separately from the outcomes of the organization;
(2) Competent employee recruitment and proper management to negate negative impacts;
(3) Presence of a formal business structure within the organization (manager or department).

Depending on the organizational needs, a certain balance between general management and innovation management needs to be present. In the following paragraph, the characteristics of the organization are discussed that influence the organizational needs.

9.3.5 Organization

An organization is a collection of resources that aim to achieve a certain purpose in a market. Organizational resources can be defined as capabilities and assets (Berkowitz 2018). The degree to which the capabilities and assets of an organization can exchange capabilities and assets is known as absorptive capacity (Buliga et al. 2016; Caiazza 2017; Malik and Bergfeld 2015). The absorptive capacity is highly dependent on the organizational structure and the organizational functions.

9.3.5.1 Absorptive Capacity

Absorptive capacity (AC) is the ability of an individual to evaluate, learn, apply and enhance new knowledge, artefacts, and skills (Malik and Bergfeld 2015; Phuc 2015). AC is in essence, the ability to communicate knowledge and therefore involves a sender and a receiver. The absorptive capacity of individuals is determined by their background, technological expertise, and level of communication with other internal and external individuals (Malik and Bergfeld 2015). The higher the difference in AC characteristics between two individuals, the more difficult it will be to communicate knowledge between sender and receiver. Several factors influence AC, which is, the number of iterations in communication, the background of the sender and receiver, the method of communication, the quality of the communication, and the technological level of expertise (Malik and Bergfeld 2015). The ability of individuals to communicate knowledge is therefore dependent on the organizational structure and organizational functions.

9.3.5.2 Organizational Structure

The organizational structure consists of different organizational components and their relationship with each other. Each organizational component consists of capabilities and assets structured in a way that should fit her spatial, industrial, and technological context (Caiazza 2017). The spatial context of an organization can be described as the geographical distance between different organizational components (Caiazza 2017). The spatial distance influences the ability of an organization to transfer knowledge between organizational components (Caiazza 2017). The industrial context indicates the distance in industries between organizational components (Caiazza 2017). New ideas can be introduced to different industries, creating a new application in the new industry (Caiazza 2017). Finally, the technological context indicates the scope of technological domains, in which the organization is present (Caiazza 2017). A larger variety in technological domains can have a positive effect on the competitiveness of the organization (Caiazza 2017).

9.3.5.3 Organizational Functions

The function of the different organizational components consists of exploration and/or exploitation activities (Buliga et al. 2016). Ambidexterity is the ability of an organization to exploit existing business activities and explore new opportunities simultaneously (Buliga et al. 2016). Both existing business activities and new opportunities can be mapped via a business model (Barth et al. 2017; Shao et al. 2014). To achieve ambidexterity, two approaches are feasible, namely structural or contextual approach (Buliga et al. 2016). Structural approaches separate the exploration from the exploitation part of the organization either via a separate organizational component or by setting fixed times for individuals to explore innovations (Buliga et al. 2016). Contextual approaches aim to create an adequate environment where ambidextrous behavior is encouraged via trade-offs or via a balance (Buliga et al. 2016). When products/services are developed that have little in common with existing exploitation activities, a spatial approach to ambidexterity is advisable (Buliga et al. 2016).

Depending on the market needs and organizational desires, different degrees of AC can result. In the following paragraph, the strategic interface is discussed, which consists of protective and advancing strategies, to acquire the desired market position of the organization.

9.3.6 Strategic Interface: Desired Market Position

Strategy is defined as the direction of an organization to achieve its desired position in a market. Strategic decision-making involves a dynamic process between the internal and external forces of an organization (Gaziulusoy and Brezet 2015). A distinction in

strategies can be made between protecting the existing market position and advancing the market position of an organization (Mulyaningsih et al. 2016).

9.3.6.1 Protective Strategies

Strategies to protect the market position involve among others, increasing the entrance level of potential competitors, fast imitation of market leaders mitigating the investment costs in innovations, or by monopolizing the supply chain minimizing market access for competitors (Phuc 2015). Increasing the entrance level for competitors involves an efficiency advantage relative to competitors. This can be achieved via advantages of scale or advantages in product/service delivery technology. Fast imitation requires a high level of absorptive capacity of an organization. Monopolizing the supply chain involves committing supply chain partners to exclusively use the products/services from the organization.

9.3.6.2 Advancing Strategies

The Ansoff matrix provides a categorization of advancement strategies (De Waal 2016, see Fig. 9.4: The Ansoff matrix). The Ansoff matrix consists of two dimensions, namely markets and products/services. Each dimension distinguishes between present and new, resulting in four strategies: (1) *market penetration* involves selling present products/services to present markets. Developing a brand identity to profile the organization can be a viable approach to market penetration (Botschen and Wegerer 2017; Christofi et al. 2015). (2) M*arket development* involves introducing present products/services to new markets. Market development involves convincing a new market of the value of existing products and services. (3) P*roduct development* involves new products/services for present markets. (4) *Product/market diversification* involves offering new products/services to new markets (De Waal 2016). Depending on the market, certain strategies may prove more viable than others. Therefore, market characteristics

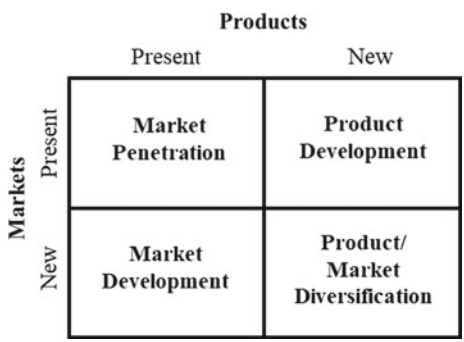

Fig. 9.4 The Ansoff matrix. Adapted from De Waal 2016

should be taken into account to select appropriate strategies. In the following paragraph, different market characteristics are discussed.

9.3.7 Market

An organization aims to provide value to its customers in a sustainable way (Periac et al. 2018). This paragraph will discuss different characteristics of the market that influence the expectations of value. The relevant topics are the market scope, the influence of institutions, the market competition, and finally, different types of collaboration partners.

9.3.7.1 Market Scope

The geographical location and market sector influences the definition of value and the involvement of market stakeholders (Maier et al. 2016; Tariq et al. 2017). The geographical scope influences the physical environment and cultural norms of the market (Dubina et al. 2017; Kumar 2014; Tang et al. 2015). Developed, developing, and emerging countries possess different expectations towards performance (Tang et al. 2015). The sector can be separated into public-private, business-to-business and a business-to-consumer context. The sector influences the focus of value that is created, focusing on either the general public, a business, or the consumer, respectively (Arshad and Su 2015; Coutelle-Brillet et al. 2014).

9.3.7.2 Institutions

Institutions can influence the market by enabling or constraining innovations (Cajaiba-Santana 2014). Examples of institutions are universities, public research centers, and public administration offices (Morrar 2015). Enabling factors can be in the form of knowledge factors, such as intellectual property, technical competencies, and education, or financial factors, such as funding, providing incentives, and providing procedures to mitigate financial risks (Dubina et al. 2017; Maritz et al. 2014; Morrar 2015; Somers and Stapleton 2014; Tariq et al. 2017). Enabling factors aim at stimulating the innovations in a market. Constraining factors involve procedures to minimize the negative impact of innovation and to keep market competition fair (Cajaiba-Santana 2014). Constraining factors can be in the form of laws and regulations, which can be set on regional, national, transnational and global scales (Binz and Truffer 2017).

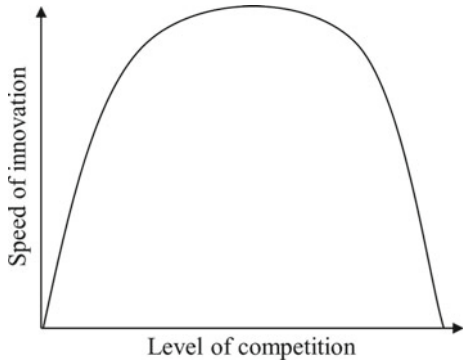

Fig. 9.5 An inverted U-shape. Adapted from Phuc 2015

9.3.7.3 Competition

The speed at which new innovations enter the market has been found to be dependent on the level of competition on the market (Phuc 2015). This can be explained by the need of an organization to stay ahead of its competitors. In a monopoly, the need for innovation is non-existent, since the organization provides the only offering on the market. In an oligopoly, the need to innovate is high, since a relatively small amount of organizations compete for their market share. In an open market, the need for innovation is low, since imitation of a market leader can occur rapidly. Investments in innovations, in this case, do not enable long-term competitive advantage. An inverted U-shape has been found to represent the speed of innovation, influenced by the level of competition on the market (see Fig. 9.5: an inverted U-shape, Phuc 2015). In other words, no competition leads to no incentives for innovation, too much competition discourages innovation, since competitors have the ability to imitate the innovation from the innovator. Not too much and not too little competition leads to the most innovations in a market, also known as the "Goldilocks zone" (Phuc 2015).

9.3.7.4 Collaboration Partners

In order to collaborate, people, knowledge, and capital are shared between partners (Binz and Truffer 2017; Troilo et al. 2017). In order to be effective, the number of collaborations should not be too many nor too little (Grubb et al. 2017). Interactions between the market and the organization can take place in a formal, informal, and social setting (El-Griffin 2015). There are different types of formal collaborations that can occur on a market, based on the partner (Lager 2017). Collaborations can occur with customers, business ecosystems, innovation networks, and supply chains.

Collaborations with large groups of customers are known as crowdsourcing and can be used for developing specific solutions, customization of product and services, and developing innovations (Zhang et al. 2015). Crowdsourcing can take on differ-

ent forms, such as competitions, platforms, and communities (Zhang et al. 2015). Business ecosystems consist of organizations with complementary capabilities and focus on diversity to progress each other's position in the market and the market as a whole (Rinkinen and Harmaakorpi 2018). Business ecosystems as a whole aim to create a shared value to the market. This mainly consists of peer-to-peer activities (Zhang et al. 2015). Innovation networks consist of partners that aim to develop innovations with a high potential (Rinkinen and Harmaakorpi 2018). The outcome of innovation networks can result in the development of new businesses (Zhang et al. 2015). Finally, the supply chain can be identified. The supply chain involves roles such as suppliers, logistics, distribution, and customers (Lee 2015; Liu et al. 2017; Mansour and Barandas 2017; Rodriguez and Da Cunha 2018). The supply chain aims to improve the flow of goods, services, and information from supplier to the customer and from the customer back to the supplier, if necessary.

Now that an inventory is made of the different factors that can contribute to innovations, a case study is performed on an innovative Dutch railway service organization, to identify the factors that contribute to the high pace of innovations.

9.4 Case Study

In this section the innovation framework will be applied to an innovative Dutch railway Service Provider (SP), which is active in a large part of The Netherlands, to identify the factors that have led to the high pace of innovation. Since the SP is developing many innovations, the conceptual innovation framework will be applied top-down, starting with the market of the SP. Each level of the innovation framework will conclude with a short analysis.

9.4.1 Market

In this paragraph, the market of the SP will be discussed. The market scope, relevant institutions, level of competition, and collaboration partners of the SRDP will be described and analyzed.

9.4.1.1 Market Scope

The SP is situated in several countries throughout the world, with her headquarters situated in The Netherlands. The Netherlands has the busiest railways in Europe, transporting 1.1 million daily commuters over a distance of 152 million train kilometers annually and freight trains cover distance of 6 million kilometers on an annual basis (ProRail 2018). The main Dutch railway network costs 1310 million Euros per year to maintain (ProRail 2018). Maintenance on the main Dutch railway infras-

tructure is divided into 21 contract areas. The SP in this case study is one of the largest privately owned railway maintenance service provider in the Netherlands. The Netherlands is part of the developed world and as such, sets high standards on the performance of the railways (Dubina et al. 2017; Kumar 2014; Tang et al. 2015). The sector of the SP in The Netherlands can be identified as Public–Private, since the customer of the SP on the Dutch market is ProRail. Therefore, the focus of value is aimed at the interpretation of the general public (Arshad and Su 2015; Coutelle-Brillet et al. 2014). ProRail is a state-owned institution, which carries the responsibility of operating and maintaining the Dutch railways.

9.4.1.2 Institutions

The railways in the Netherlands are managed by separate entities and fall under the responsibility of ProRail, for the railway infrastructure, and NS (de Nederlandse Spoorwegen, The Netherlands Railways), for the passenger rolling stock. Both organizations are 100% state-owned. Governance of the railway in The Netherlands is executed by the Dutch ministry of Infrastructure and Waterways (I&W). Oversight and control of laws that involve the quality of the Dutch railways is enforced by the ILT (Inspectie Leefomgeving en Transport, Inspection for living environment and transport) organization (Binz and Truffer 2017; Cajaiba-Santana 2014). The ILT reports directly to the ministry of I&W, which is a public administration office (Morrar 2015).

In 2009 ProRail introduced performance-based contracts, leading to the DR and her competitors obtaining the responsibility to improve railway infrastructure performance. The introduction of the new contract form enables the SP to innovate, due to financial factors (Cajaiba-Santana 2014; Dubina et al. 2017; Maritz et al. 2014; Morrar 2015; Somers and Stapleton 2014; Tariq et al. 2017). Prior to the performance-based contracts, competitors were appointed a contract area and performed actions as described by ProRail. Suppliers of railway-related products and services require certification by ProRail. With regards to data, ProRail aims to ensure fair competition. Certification and fair competition are regulations that can constrain participation in innovations (Binz and Truffer 2017; Cajaiba-Santana 2014).

9.4.1.3 Competition

The SP is situated in an oligopoly, competing against three other certified SPs. Therefore, the level of competition of the market of the SP is within the “Goldilocks zone”, where competition is not too low, nor too high, predicting a high speed of innovations (Phuc 2015). Contracts between ProRail and SPs are selected via a reverse tendering procedure. Based on bonuses for the performance offered, the economically most advantageous bid wins the contract after ProRail is satisfied with how the SP aims to achieve the competitive bid. Contracts last for a period of five years and are evaluated quarterly on their performance, which can result in bonuses or fines.

9.4.1.4 Collaboration Partners

To compete on the market, the SP has several partners. The SP collaborates in all four collaboration types, namely: customers, business ecosystem, innovation networks, and supply chain. Customers include ProRail, as well as international customers (Zhang et al. 2015). In the business ecosystem, collaborations with strategic partners can be identified (Rinkinen and Harmaakorpi 2018; Zhang et al. 2015). Innovation networks include European funded projects and research initiatives with the University of Twente (Rinkinen and Harmaakorpi 2018; Zhang et al. 2015). In the supply chain, the SP collaborates with suppliers of products and services (Lee 2015; Liu et al. 2017; Mansour and Barandas 2017; Rodriguez and Da Cunha 2018). Therefore, many collaborations take place within the SP (Binz and Truffer 2017; Troilo et al. 2017). However, whether too many collaborations take place, is difficult to determine, since this is highly context-dependent and would require a competitor analysis (Grubb et al. 2017).

9.4.1.5 Market Analysis

The SP is situated in a demanding railway market and is positioned in a sector, which is focused on serving the general public. The introduction of performance-based contracts has increased the need of the SP to innovate her services and products. Situated in an oligopoly, the level of competition is within the so-called "Goldilocks zone", predicting a high speed of innovation. The SP takes full advantage of the different types of collaboration partners to accelerate innovations. However, to determine whether too many collaborations take place would require a competitor analysis, which is outside of the scope of this research (Grubb et al. 2017).

9.4.2 Strategic Interface: Desired Market Position

In this paragraph, the strategies of the SP will be discussed. First, the overall strategy of the SP will be introduced, followed by a description and analysis of both protective and advancing strategies the organization uses.

9.4.2.1 Overall Strategy of the Dutch Railway Service Provider

The SP's motto is "Making rail transport safe, available, efficient and sustainable" creating attractive rail transport. Attractive rail transport is in their vision :

- aimed at the passenger;
- safe, on time and reliable;
- competitive with road, ship and air transport;
- and sustainable: energy-saving and environmentally friendly.

Overall, the SP aims to be a competitive and innovative service provider. To do so, the SP's strategy is to: "*use the competitive market of the Netherlands to innovate, so that they [the innovations] can be marketed abroad*" *(Director).* To enable this strategy, the SP uses both protective and advancing strategies.

9.4.2.2 Protective Strategies

Since the Dutch market plays a critical role in fulfilling the strategy of the SP, two protective strategies are used, namely: increasing the entrance barrier for competitors and monopolizing strategic partners (Phuc 2015). Increasing the entrance barrier is naturally achieved by continuously innovating the products and services, which the SP provides the Dutch railway market. In addition, the SP monopolizes strategic partners, both nationally and internationally, by building relationships with partners which hold promising new technologies.

9.4.2.3 Advancing Strategies

The chosen strategy of the SP, in combination with her market characteristics, enables the use of three types of advancing strategies to improve her position. Market penetration, product development, and market development advancing strategies are used by the SP (De Waal 2016). The application of multiple advancing strategies requires continuous development of new products and services for existing and new markets. Developments in products and services in the SP focus on:

- data acquisition;
- data analysis and decision support; and
- maintenance execution.

Since the contracts from ProRail are based on reverse auctioning in combination with performance for a period of five years, the SP has obtained more responsibilities, which enables a further decrease in maintenance costs and reduction in failures, in comparison with the bids which results in bonuses. Reverse auctioning in combination with the performance-based contracting, enables the market penetration strategy on the Dutch market. In addition, this strategy is also viable for present international markets, which do not use performance-based contracts. For an additional fee the present international market can be sold a new product or service, in addition to existing products and services that are provided by the SP. The extra investment can result in an additional decrease in downtime and costs. The foci of the SP with regards to

product/service development, enables the establishment of a brand identity specialized in maintenance, further enabling the market penetration strategy (Botschen and Wegerer 2017; Christofi et al. 2015).

Since not all railway owners in the world, are familiar with the products and services of the SP, the market development strategy can be executed. Each additional product and service the SP is able to offer to potential new markets provide a new selling point for the SP. Once a new market adopts a single product or service from the SP, the market penetration strategy can be applied to the new market. Expansion from heavy public transportation to light public transportation and heavy private transportation has been realized in recent years. Therefore, the product/market diversification strategy is not used within the SP, since the new market is still rail related (De Waal 2016).

9.4.2.4 Strategic Interface Analysis

The SP uses a wide array of strategies to improve her position on both the present market and new markets. The only two strategies that are not used by the SP are imitating market leaders and product/market diversification. Exclusion of the imitating market leaders strategy can be explained by the leading position of the SP. Exclusion of the product/market diversification strategy indicates that the SP has a clear focus on the type of products and services it wants to develop and displays a commitment to the railway service market (De Waal 2016).

9.4.3 Organization

In this paragraph, the organization of the SP will be discussed. The absorptive capacity (AC), organizational structure, and functions with regards to innovation of the SP will be described. This paragraph will end with an analysis of the organization of the SP.

9.4.3.1 Absorptive Capacity

The ability of individuals to transfer knowledge, also known as AC, varies within the organization (Malik and Bergfeld 2015; Phuc 2015). More experienced personnel have operational experience. However, since the organization is growing, new personnel have little to no operational experience. Depending on the individuals between who knowledge is transferred, the AC can be high or low. However, during the development of new products and services, the interaction between organizational components is high and in general, face-to-face. In particular, individuals who have collaborated with each other in the past, the AC is high.

9.4.3.2 Organizational Structure

The SP consists of over 3000 FTEs (Full-time equivalents). The SP is part of a larger privately owned organization. The headquarters of the SP is situated in The Netherlands and each contract area has in general, its own production location. Therefore the geographical distance between organizational components is relatively high, negatively impacting the AC of the organization (Caiazza 2017). The SP focuses on rail systems, while her sister companies focus on other industries, such as civil infrastructure, and technical installations and facilities. Therefore, a high distance in the industrial context of the SP is present, positively influencing the ability to transfer applications to new industries (Caiazza 2017). With regards to technology, the SP has outstanding expertise in information communication technology, maintenance engineering, and condition monitoring technologies, indicating a high variety in technological domains, positively influencing the ability to create and absorb new knowledge (Caiazza 2017).

9.4.3.3 Organizational Functions

The exploration of new products and services fall under the responsibility of two organizational components, namely Asset Management (AM) and Operations Rail (OR), which also exploit services and products respectively (Buliga et al. 2016). Therefore, both organizational components are ambidextrous (Buliga et al. 2016). OR takes a structural approach to ambidexterity, by setting fixed times to explore and support developments (Buliga et al. 2016). AM approaches ambidexterity via a contextual approach, by balancing both internal and external customer service requests with new product and service developments (Buliga et al. 2016). Within the SP, only new opportunities are mapped via a business model (Barth et al. 2017; Shao et al. 2014).

9.4.3.4 Organization Analysis

The spatial distance between different organizational components of the SP is relatively high. However, because the AC of individuals within the organization can be high, communication of knowledge is not always a challenge within the organization. The industrial context of the SP is focused on rail systems, however knowledge exchange between sister companies and strategic partners enable new idea combinations, resulting in new applications. The technological context indicates a relatively high variety in technological domains, which increases the competitiveness of the organization. Ambidexterity takes place in two organizational components, which means that users of new products and services are also involved with the development of new products and services. Business models are only used for mapping new opportunities and not for existing business activities (Barth et al. 2017; Shao et al. 2014).

9.4.4 Tactical Interface: Organizing the Innovation Process

In this paragraph, the tactical interface of the SP is discussed. The different responsibilities of general management that influence the SP are described, followed by the innovation management of the SP. This paragraph will end with an analysis of the tactical interface of the SP.

9.4.4.1 General Management

Standardization of new business processes occurs on different levels and are managed by different internal or external organizational components (Arshad and Su 2015; Bélanger et al. 2016). The different roles of general management of the SP can be identified as (1) the customer ProRail, (2) managers of the different functional units in the central organization, and (3) the production managers of the different contract teams. Each layer of general management carries the responsibility over a different process, which are: (1) the reverse auctioning process and evaluation of the performance during a contract, (2) developing the competitive bid and maintenance planning, and (3) standardization of the daily processes, respectively. Since all roles are fulfilled by multiple individuals, each with a variation in planning horizon, transparency, and regulation is difficult to achieve within the SP (Bélanger et al. 2016; Hashmi et al. 2017; Overall 2015). Therefore, an aggressive approach to control is not present, enabling creativity among employees (Overall 2015).

9.4.4.2 Innovation Management

The SP possesses two ways of collecting ideas for innovations from employees. By facilitating an internal idea platform and through general management, new ideas can be developed. Employees are involved in innovation in several ways, namely in the generation, selection, development, testing, and implementation of ideas. An idea platform enables employees to submit ideas freely, or according to challenges. Therefore support for adopting new products/services are stimulated with employee involvement (Arshad and Su 2015; Weisberg et al. 2014).

Since general management roles are fulfilled by multiple individuals and are given the ability to use creativity, general management can be identified as intrapreneurs (Arshad and Su 2015; Hastuti et al. 2016). The SP has centralized its business structure with regards to innovations, appointing an innovation manager to coordinate both R&D and implementation activities. Therefore, a formal business structure is present within the SP (Sindakis 2015). The management of the idea platform takes place within the innovation business structure.

9.4.4.3 Tactical Interface Analysis

General management within the SP displays a high level of variety, since general management activities are organized by production managers, serving multiple customer organizations. Organizing innovations requires collaborations between general and innovation management within the SP. Autonomy in participation in innovations is high for the different production managers, enabling a secondary selection filter for new products/services. The formal innovation business structure enables a high level of employee involvement in the generation, selection, testing, and implementation of innovations. However, evaluation of the outcomes of innovations, as well as the recruitment and management of intrapreneurs, can be improved within the SP (Sindakis 2015).

9.4.5 Process

In this paragraph, the innovation process of the SP is discussed. First, the exploration process is discussed, followed by the exploitation process. This paragraph will end with the analysis of the innovation process of the SP.

9.4.5.1 Exploration

Identification and generation of ideas within the SP are communicated via the general management or the internal idea platform. Selection of ideas occurs within the innovation business structure and is based on strategic contribution, risks, costs, and benefits. Therefore, ideas are selected for development according to the strategy of the SP (Chernoivanova 2015). Since the resources for developing and implementing innovations are limited, the SP sets hard criteria for selecting innovations. Of hundreds of initial ideas, only a limited amount is in development. Therefore, the idea generation and enrichment, and idea selection process steps are present in the SP (Bélanger et al. 2016; Chernoivanova 2015; Mulyaningsih et al. 2016; Takey and Carvalho 2016; Zhang et al. 2015).

Depending on the size of the investment, approval is required from a business unit manager, strategic business unit director, the board of directors of the organization, or external funding. The concept definition and business feasibility are captured on a single page and include the required internal and external investment in resources and capacity, potential profit, and risks associated with the innovation. Once approved, the required internal or external resources are organized to develop the product. Therefore, the process steps concept definition, business feasibility, and organizing capabilities and assets are present in the SP (Bélanger et al. 2016; Buliga et al. 2016; Mulyaningsih et al. 2016; Takey and Carvalho 2016).

9.4.5.2 Exploitation

Whether an innovation is intended for the national or international market, innovations are implemented and evaluated on the national market, via a pilot, prior to further exploitation. In case a product/service is applied on the Dutch railway infrastructure, permission, and certification are required from ProRail. For further exploitation, a distinction can be made for the national and international market.

For the national market, the national sales department, implementation department, and contract areas play a critical role. The national sales department receives an overview of the innovation manager, which presents the latest innovations. The national sales department analyses the failures that occurred within a contract area and deducts failures, based on the evaluation of a specific innovation in a pilot contract area. A reduction in failures contributes to a bonus in the tendering process, which increases the odds of winning a contract area. With the support of the implementation department, a contract area implements innovations.

For the international market, the international sales department and customer organization play an important role. Existing customers are approached by employees of the international sales department, to adopt new products and services. If required, additional development and implementation resources are allocated to support the customer organization to adopt the innovation. For both the national and international market the implementation process step is identified in the SP (Bélanger et al. 2016).

9.4.5.3 Process Analysis

The SP executes most of the process steps that are required to innovate. Hard selection criteria ensure that from competing ideas, only the most promising ideas that align with the strategy of the SP, make use of the scarce resources for development and implementation. Exploitation of innovations occurs on both the national and international market and is organized under different organizational departments. The process steps opportunity identification and evaluation, however, were not formalized within the SP during this case study (Bélanger et al. 2016; Buliga et al. 2016; Mulyaningsih et al. 2016; Takey and Carvalho 2016).

9.4.6 Operational Interface: Developing Products/Services

In the following paragraph, the four categories of the innovation activities are described. The categories market research, development, sponsor, and knowledge management of the SP are described, followed by an analysis of the operational interface of the SP.

9.4.6.1 Market Research

Depending on the problem owner, different organizational components provide input for market research. On the national market, input for market research is provided by three organizational components, and include the national sales department, the contract areas, and the asset management department. A problem can be indicated by an employee in a contract area. Consequently, data analysis can indicate the size of the problem on the entire national market, performed by asset management. The national sales department indicates the financial bonuses the customer offers for a decrease in failures. By combining the input of the market research, an estimation of the size of the investment can be calculated.

On an international market, the customer, international sales, and asset management provide input for the market research. Similarly, as the market research on the national market, the customer indicates the problem, which can be validated by asset management. The international sales department provides an indication of the potential market of a solution and an indication of how much the customer is willing to pay for the development of a solution, which is combined into an estimation of the size of the investment.

Both national and international sales scan the market on existing solutions, followed by a business feasibility study. If approved by the sponsor, innovation enters the development activities. Therefore, market research is present within the SP. The targeted user, problem definition, research into existing solutions, and a business feasibility study are present in new product/service documentation (Bélanger et al. 2016; Mulyaningsih et al. 2016; Takey and Carvalho 2016; Zhang et al. 2015).

9.4.6.2 Development

Together with the customer or employees, requirements for the solution are defined. Internal and external resources are organized to develop the product or service. Depending on the required resources for development, the internal resources are supplemented or outsourced to external partners. Tests and demonstrations are performed on a pilot contract area if needed. The implementation, in general, always takes place in a Dutch contract area, to obtain in-house experience and to ensure the operational application of the innovation. The development team collaborates with a contract area to validate the use of innovation. Documentation about the development of new products/services includes solution requirements and user involvement (Bélanger et al. 2016; Buliga et al. 2016; Kuzmin and Grom 2014; Weisberg et al. 2014; Zhang et al. 2015).

9.4.6.3 Sponsor

Dependent on the size of investment, the sponsor is a business unit manager, strategic business unit director, a member of the board of the organization or an external party.

The sponsor of innovations has several decision-making moments in the innovation process, which are after the business feasibility study, indication of partner development costs (if present), and the innovation implementation process step. The sponsor of the SP carries the responsibility of negotiating innovation ownership, intellectual property rights and commercial agreements if external partners support the development process via resources or capacity. Therefore, the investment and division of benefits are present in new product/service documentation (Erzurumlu 2017; Morrar 2015; Mulyaningsih et al. 2016; Rinkinen and Harmaakorpi 2018; Takey and Carvalho 2016; Troilo et al. 2017). In addition, the sponsor reviews the new product/service during development and prior to commercialization (Buliga et al. 2016; Malik and Bergfeld 2015).

9.4.6.4 Knowledge Management

A central location, where innovation documents are stored is present within the SP. Each innovation describes the innovation, its team members, sponsor, and status of the innovation, allowing efficient retrieval of documentation. The documents include general information, the current state of the context, the desired state of the context, the chosen solution to achieve the desired state, and a business feasibility study (Erzurumlu 2017; Malik and Bergfeld 2015; Rinkinen and Harmaakorpi 2018; Troilo et al. 2017). Innovations that are approved, are monitored on their progress and documentation is updated when required.

9.4.6.5 Knowledge Management

The innovation process of the SP has different inputs and outputs, with regards to the national and international market. Regardless of the market, a high degree of collaboration between internal and external organizational components is required to innovate successfully. The sponsor carries the responsibility of approving innovations within the SP, prior to committing resources to its development and exploitation. The importance of knowledge management is recognized within the SP, which falls under the responsibility of the innovation manager and is indicated by the presence of a central library for innovations. However, three points of improvement are possible for the documentation of new products/services in the SP. First of all, investments of organizational resources mainly focus on financial resources, rather than the investment in human resources (Erzurumlu 2017; Morrar 2015; Mulyaningsih et al. 2016; Rinkinen and Harmaakorpi 2018; Takey and Carvalho 2016; Troilo et al. 2017). Second, the generation of alternative solutions for a problem is not present in the reviewed documentation (Chernoivanova 2015; Takey and Carvalho 2016; Zhang et al. 2015). Finally, evaluation of requirements, unforeseen challenges and problems are not found in the reviewed documents (Bélanger et al. 2016; Buliga et al. 2016; Kuzmin and Grom 2014).

9.4.6.6 Product/Service

In this paragraph, the Predictive Maintenance and Fault Diagnostic System (FDS) of the SP will be presented. The FDS is one of many innovations of the SP and illustrates the experience of the SP with regards to innovating. The FDS has gone through all innovation types and is still further developed by the SP. To illustrate the differences in effort per innovation type, each transition is shortly described. Effort in transitions involve changes in technology, organization, products, and processes. The paragraph will start with an introduction of the FDS, followed by the effort required to transition the system from radical to modular, from modular to architectural, and from architectural to incremental innovation. This paragraph will end with an analysis of the product/service.

9.4.6.7 Fault Diagnostic System

The FDS is a non-intrusive and easy to install the system, which measures the power consumption of any electrical system it is connected to. By registering power consumption patterns and relating them with failures, potential failures can be identified before they occur. The FDS is a condition monitoring system, which enables a significant reduction in failures. In addition, the FDS supports maintenance personnel by indicating the type of failure, enabling more efficient failure diagnosis and spare parts logistics, leading to faster recovery of the infrastructure.

9.4.6.8 From Radical to Modular

The measuring of power consumption to enable condition monitoring, was a radical innovation in railway maintenance around the year 2000 (Caputo et al. 2016; Coutelle-Brillet et al. 2014; Gaziulusoy and Brezet 2015; Mulyaningsih et al. 2016; Phuc 2015). Prior to the FDS, railway switch motors were replaced preventively, incurring high costs in their replacement. Originally, the SP developed the FDS to indicate a switch motor failure after it occurred, as a module on the infrastructure (Caputo et al. 2016; Coutelle-Brillet et al. 2014; Gaziulusoy and Brezet 2015). Certification of the FDS required close collaboration with ProRail, in order for the system to be certified.

9.4.6.9 From Modular to Architectural

In time, the potential of the FDS to indicate failures in advance was recognized by the SP. However, the product on itself was not sufficient to support users of the system. The SP required attention on its data acquisition, in order to match and validate failures with patterns in the power consumption of a railway switch motor. In order for the FDS to be of utility in other physical environments, the architecture

of FDS required a revision. Apart from the product, the software services "Analysis" and "Manager" were developed to support track workers, maintenance engineers and failure management personnel (Troilo et al. 2017). Therefore, the failure data acquisition, data analysis, and decision support were additional modules, that were required to complete the FDS architecture (Caputo et al. 2016; Coutelle-Brillet et al. 2014; Gaziulusoy and Brezet 2015; Hastuti et al. 2016; Phuc 2015).

9.4.6.10 From Architectural to Incremental

Incremental innovation can be identified in the scope of the application of the system, and the depth of the system (Caputo et al. 2016; Coutelle-Brillet et al. 2014; Gaziulusoy and Brezet 2015; Phuc 2015). Now that the FDS architecture has matured, the applications of FDS are expanded to other electrical systems, such as level crossings, track sections, as well as rolling stock. Therefore, the scope of FDS is increased. For each application, the library of failures and power consumption patterns increases. This allows more accurate decision support for maintenance personnel and railway operators.

9.4.6.11 Product/Service Analysis

The FDS consists of a combination of products and services. The effort required to arrive at a modern-day application of the FDS was enabled by the market, organization, organizational processes, and products and services. Expansion of its application required the development of additional modules, which resulted in the modern day architecture of the FDS. In order for the FDS to be useful in its new contexts, previous lessons learned have to be applied to the new contexts. The SP has the experience to innovate products/services through their entire lifecycle to provide value to its users (Caputo et al. 2016; Coutelle-Brillet et al. 2014; Mansour and Barandas 2017; Rinkinen and Harmaakorpi 2018; Troilo et al. 2017).

9.5 Summary and Implications

This research set out to identify the factors that contribute to the high pace of innovations in the Dutch railway organizations. To do so, a conceptual innovation framework is constructed from theory and a case study is performed on an innovative Dutch railway Service Provider (SP). The case study reveals that a combination of factors contributes to the high pace of innovations in the SP. This paragraph will summarize the case study findings, followed by the limitations of the research. This chapter ends with implications for practitioners and researchers.

9.5.1 Summary

Several factors contribute to the high pace of innovations for the SP, which have been categorized as market, strategic interface, organization, tactical interface, process, operational interface, and product/service factors.

Market factors that contribute to the high pace of innovations include: high expectations on the performance of railways in the Netherlands, in a sector which serves the general public; the introduction of performance-based contracts, which has increased the need to innovate to compete; appropriate levels of competition, which does not demotivate nor stifle innovations; and close collaborations with different types of partners. However, whether too many collaborations in innovations are present within the SP, requires competitors analyses, since the optimum number of collaborations is context dependent.

With regards to the strategic interface, the SP uses a wide array of strategies to protect the present market and to advance her market position, which all focus on the development of new products and services for the railway market. A clear focus on the type of products and services in combination with a commitment to the railway service market enables the organization to cope with the mix of strategies.

Organizational factors contribute to the exchange of knowledge within and outside of the SP. Despite the high spatial distance of the organization, communication between organizational components can be enabled by operational experience of developers. In addition, knowledge exchange between sister companies and variety in technological context increase the competitiveness with regards to innovations via combining new ideas. Two organizational components are structured to enable ambidexterity, indicating that they are involved in both the use and development of new innovations. New opportunities are mapped via business models, however not for existing business activities.

The tactical interface of the SP displays a high level of variety, since production managers serve multiple customer organizations. Organizing innovations involves both general and innovation management. A secondary selection filter is enabled by the autonomous decision-making due to the production managers, ensuring that only promising innovations are adopted. The innovation business structure of the SP enables a high level of employee involvement. However, evaluation of the outcomes of innovations, as well as the recruitment and training of intrapreneurs can be improved.

The innovation process of the SP contains most of the process steps required to innovate successfully. Hard selection criteria ensure that only the most promising ideas make use of scarce organizational resources. Within the SP, exploitation occurs on both the national and international market and are organized in different organizational departments. However, the innovation process steps of opportunity identification and evaluation require formalization in the SP.

The operational interface of the SP shows a high degree of collaborations between internal and external organizational components. The sponsor of an innovation plays an important role in approving innovations and the commitment of organizational

resources. To manage the knowledge gained in innovations, documents are stored in a central library. However, three improvements can be made in the documentation with regards to innovation development: (1) estimated investments in human resources, (2) generation of alternative solutions for a problem, and (3) evaluation of requirements, unforeseen challenges, and problems.

The SP has experience in transitioning a radical innovation all the way to an incremental innovation. To do so, the market, the organization, organizational processes, and products and services have enabled the transition. This has resulted in an architecture for a fault diagnostic system, which can be applied to different contexts. Therefore, the SP has the experience to innovate products/services through their entire lifecycle to provide value to its users.

9.5.2 Limitations of the Study

This research has two main limitations, namely the applied methodology and the data obtained from the case study. The coding methodology used in this study is potentially under the influence of researcher's bias, indicating that the development of the presented framework can be dependent on the background of the authors (Saldaña 2015). The case study data used in this study has been selected by the case study organization, therefore can be unrepresentative for the case study organization.

9.5.3 Implications

The presented research shows that the Dutch railway sector is a sector which deserves further research on maintenance practices. The presented framework is a step towards an holistic innovation management framework which can be used to analyze innovations on a sector level. The research results give practitioners insights on how to develop innovation management practices in the railway sector.

Future research can focus on validating the presented innovation framework, in order to reach consensus. In addition, research is required, to determine the optimum amount of innovations and collaborations for an organization.

References

Arshad, A. M., & Su, Q. (2015). Interlinking service delivery innovation and service quality: A conceptual framework. *Journal of Applied Business Research, 31*(5), 1807–1822. https://doi.org/10.19030/jabr.v31i5.9393.

Barth, H., Ulvenblad, P. O. & Ulvenblad, P. (2017). Towards a conceptual framework of sustainable business model innovation in the agri-food sector: A systematic literature review. *Sustainability (Switzerland)* (Vol. 9, Issue 9). https://doi.org/10.3390/su9091620.

Bélanger, S., Veilleux, S., & Tremblay, M. (2016). A conceptual framework on the role of creativity in sustaining continuous innovation in new product development. *International Journal of Product Development, 21*(2/3), 190. https://doi.org/10.1504/IJPD.2016.078866.

Berkowitz, H. (2018). Meta-organizing firms' capabilities for sustainable innovation: A conceptual framework. *Journal of Cleaner Production, 175,* 420–430. https://doi.org/10.1016/j.jclepro.2017.12.028.

Binz, C., & Truffer, B. (2017). Global innovation systems—A conceptual framework for innovation dynamics in transnational contexts. *Research Policy, 46*(7), 1284–1298. https://doi.org/10.1016/j.respol.2017.05.012.

Botschen, G., & Wegerer, P. K. (2017). Brand-driven retail format innovation: a conceptual framework. *International Journal of Retail and Distribution Management, 45*(7–8), 874–891. https://doi.org/10.1108/IJRDM-10-2016-0181.

Buliga, O., Scheiner, C. W., & Voigt, K. I. (2016). "Business model innovation and organizational resilience: towards an integrated conceptual framework. *Journal of Business Economics, 86*(6), 647–670. https://doi.org/10.1007/s11573-015-0796-y.

Caiazza, R. (2017). Innovation for sustainablity: a conceptual framework. *Journal of Management Development, 36*(1), 37–47. https://doi.org/10.1108/JMD-09-2014-0099.

Cajaiba-Santana, G. (2014). Social innovation: Moving the field forward. A conceptual framework. *Technological Forecasting and Social Change, 82*(1), 42–51. https://doi.org/10.1016/j.techfore.2013.05.008.

Caputo, A., Marzi, G., & Pellegrini, M. M. (2016). The Internet of Things in manufacturing innovation processes: Development and application of a conceptual framework. *Business Process Management Journal, 22*(2), 383–402. https://doi.org/10.1108/BPMJ-05-2015-0072.

Chernoivanova, A. S. (2015). Conceptual framework for organization of innovations and innovative work. *International Business Management, 9*(6), 1063–1068. https://doi.org/10.3923/ibm.2015.1063.1068.

Christofi, M., et al. (2015). Innovation and cause-related marketing success: A conceptual framework and propositions. *Journal of Services Marketing, 29*(5), 354–366. https://doi.org/10.1108/JSM-04-2014-0114.

Coutelle-Brillet, P., Riviere, A., & des Garets, V. (2014). Perceived value of service innovation: A conceptual framework. *Journal of Business and Industrial Marketing, 29*(2), 164–172. https://doi.org/10.1108/JBIM-04-2012-0066.

De Waal, G. A. (2016). An extended conceptual framework for product-market innovation. *International Journal of Innovation Management, 20*(05), 1640008. https://doi.org/10.1142/S1363919616400089.

Dubina, I. N., et al. (2017). The balanced development of the spatial innovation and entrepreneurial ecosystem based on principles of the systems compromise: A Conceptual Framework. *Journal of the Knowledge Economy, 8*(2), 438–455. https://doi.org/10.1007/s13132-016-0426-0.

El-Griffin, E. W. (2015). Network-based resources for the innovation process of South African micro-entrepreneurs: A conceptual framework. *South African Journal of Business Management, 46*(3), 79–89.

Erzurumlu, S. S. (2017). 4Cs of innovation: A conceptual framework for evaluating innovation strategy. *IEEE Engineering Management Review, 45*(3), 42–53. https://doi.org/10.1109/EMR.2017.2734321.

Evens, G. L. (2013). A novice researcher's first walk through the maze of grounded theory: Rationalization for classical grounded theory. *The Grounded Theory Review, 12*(1), 37–55.

Gaziulusoy, A. I., & Brezet, H. (2015). Design for system innovations and transitions: A conceptual framework integrating insights from sustainablity science and theories of system innovations and transitions. *Journal of Cleaner Production, 108,* 1–11. https://doi.org/10.1016/j.jclepro.2015.06.066.

Grubb, M., McDowall, W., & Drummond, P. (2017). On order and complexity in innovations systems: Conceptual frameworks for policy mixes in sustainability transitions. *Energy Research and Social Science. Elsevier, 33*(April), 21–34. https://doi.org/10.1016/j.erss.2017.09.016.

Hashmi, A., et al. (2017). A conceptual framework for describing the innovation in teams. *International Journal of Economic Research, 14*(2), 59–72.

Hastuti, A. W., et al. (2016). The role of intrapreneurship for sustainable innovation through process innovation in small and medium-sized enterprises: A conceptual framework. *International Journal of Economics and Financial Issues, 6*(S3), 83–91. https://doi.org/10.1354/vp.45-1-73.

Kumar, V. (2014). Understanding cultural differences in innovation: A conceptual framework and future research directions. *Journal of International Marketing, 22*(3), 1–29. https://doi.org/10.1509/jim.14.0043.

Kuzmin, O. I., & Grom, O. B. (2014). Conceptual framework for express diagnostic. *Actual Problems of Economics, 1*(151), 193–202.

Lager, T. (2017). A conceptual analysis of conditions for innovation in the process industries and a guiding framework for industry collaboration and further research. *International Journal of Technological Learning, Innovation and Development, 9*(3), 189–219. https://doi.org/10.1504/IJTLID.2017.087403.

Lee, I. (2015). The internet of things (IoT) for supply chain innovation: A conceptual framework and analysis of fortune 200 companies. *Asia Pacific Journal of Innovation and Entrepreneurship, 9*(1), 81–104.

Liu, S. Y., et al. (2017). A conceptual framework for agri-food Tourism as an eco-innovation strategy in small farms. *Sustainability (Switzerland), 9*(10), 1–11. https://doi.org/10.3390/su9101683.

Maier, M. A., Brem, A., & Kauke, M. (2016). Exploring boundaries of corporate social responsibility and innovation: a conceptual framework of socio-political stakeholders and their integration into the innovation process. *International Journal of Innovation and Sustainable Development, 10*(3), 312–337. https://doi.org/10.1504/IJISD.2016.077515.

Malik, K., & Bergfeld, M. M. (2015). A conceptual framework for intra-company technology transfer: cases of leveraging production process innovations across MNEs. *Technology Analysis and Strategic Management, 27*(10), 1129–1142. https://doi.org/10.1080/09537325.2015.1060309.

Mansour, D., & Barandas, H. (2017). High-tech Entrepreneurial content marketing for business model innovation: A conceptual framework. *Journal of Research in Interactive Marketing, 11*(3), 296–311.

Maritz, A., et al. (2014). Innovation education programs: Toward a conceptual framework. *European Journal of Innovation Management, 17*(2), 166–182. https://doi.org/10.1108/EJIM-06-2013-0051.

Morrar, R. (2015). Technological Public-private innovation networks: A conceptual framework describing their structure and mechanism of interaction. *Technology Innovation Management Review, 5*(8), 25–33.

Mulyaningsih, H. D., Yudoko, G., & Rudito, B. (2016). Knowledge-based social innovation process in social enterprise: A conceptual framework. *Advanced Science Letters, 22*(5–6), 1393–1397. https://doi.org/10.1166/asl.2016.6621.

Overall, J. (2015). A conceptual framework of innovation and performance: The importance of leadership, relationship quality, and knowledge management. *Academy of Entrepreneurship Journal, 21*(2), 41–54.

Periac, F., David, A., & Roberson, Q. (2018). Clarifying the Interplay between social innovation and sustainable development: A conceptual framework rooted in paradox management. *European Management Review, 15*(1), 19–35. https://doi.org/10.1111/emre.12121.

Phuc, N. H. (2015). Imitation and innovation in emerging countries: A conceptual framework for analysis. *Journal of Innovation and Sustainability, 6*(1), 37–47.

ProRail. (2018). Annual report 2017. *Jaarverslag*, p. 164. https://doi.org/10.1021/ie2022916.

Rinkinen, S., & Harmaakorpi, V. (2018). The business ecosystem concept in innovation policy context: building a conceptual framework. *Innovation, 31*(3), 333–349. https://doi.org/10.1080/13511610.2017.1300089.

Rodriguez, L., & Da Cunha, C. (2018). Impacts of big data analytics and absorptive capacity on sustainable supply chain innovation: A conceptual framework. *Scientific Journal of Logistics., 14*(2), 151–161. https://doi.org/10.17270/J.LOG.267.

Saldaña, J. (2015) *The coding manual for qualitative researchers*. Sage.
Shao, L., Xue, Y., & You, J. (2014). A conceptual framework for business model innovation: The case of electric vehicles in China Koncepcyjne ramy dla modelowych rozwiązań biznesowych: Przypadek samochodów elektrycznych w Chinach. *Problems of Sustainable Development, 9*(2), 27–37.
Sindakis, S. (2015). Corporate venturing and customer-driven innovation in the mental health-care market: a review of the literature and development of a conceptual framework. *Journal of the Knowledge Economy, 6*(4), 1013–1033. https://doi.org/10.1007/s13132-013-0173-4.
Somers, S., & Stapleton, L. (2014). e-Agricultural innovation using a human-centred systems lens, proposed conceptual framework. *AI & SOCIETY, 29*(2), 193–202. https://doi.org/10.1007/s00146-013-0475-x.
Takey, S. M., & Carvalho, M. M. (2016). Fuzzy front end of systemic innovations: A conceptual framework based on a systematic literature review. *Technological Forecasting and Social Change., 111,* 97–109. https://doi.org/10.1016/j.techfore.2016.06.011.
Tang, M., et al. (2015). Strengthening regional integration/cooperation with the Neighbourhood System of Innovation conceptual framework: the case of China and ASEAN. *Asian Journal of Technology Innovation, 23*(2), 205–229. https://doi.org/10.1080/19761597.2015.1074511.
Tariq, A., et al. (2017). "Drivers and consequences of green product and process innovation: A systematic review, conceptual framework, and future outlook. *Technology in Society, 51,* 8–23. https://doi.org/10.1016/j.techsoc.2017.06.002.
Troilo, G., De Luca, L. M., & Guenzi, P. (2017). Linking data-rich environments with service innovation in incumbent firms: A conceptual framework and research propositions. *Journal of Product Innovation Management, 34*(5), 617–639. https://doi.org/10.1111/jpim.12395.
Villa, M. B. A. & Alzate, B. A. (2017). Entrepreneurial orientation, resources and capabilities: A conceptual framework review for innovation. *Espacios TA - TT*, (Vol. 38, Issue. 38).
Weisberg, R. W., Speck, R. M., & Fleisher, L. A. (2014). Fostering innovation in medicine: A conceptual framework for medical centers. *Healthcare, 2*(2), 90–93. https://doi.org/10.1016/j.hjdsi.2013.09.007.
Zhang, T., Kandampully, J., & Bilgihan, A. (2015). Motivations for customer engagement in online co-innovation communities. *Journal of Hospitality and Tourism Technology, 6*(3), 311–328. https://doi.org/10.1108/JHTT-10-2014-0062.