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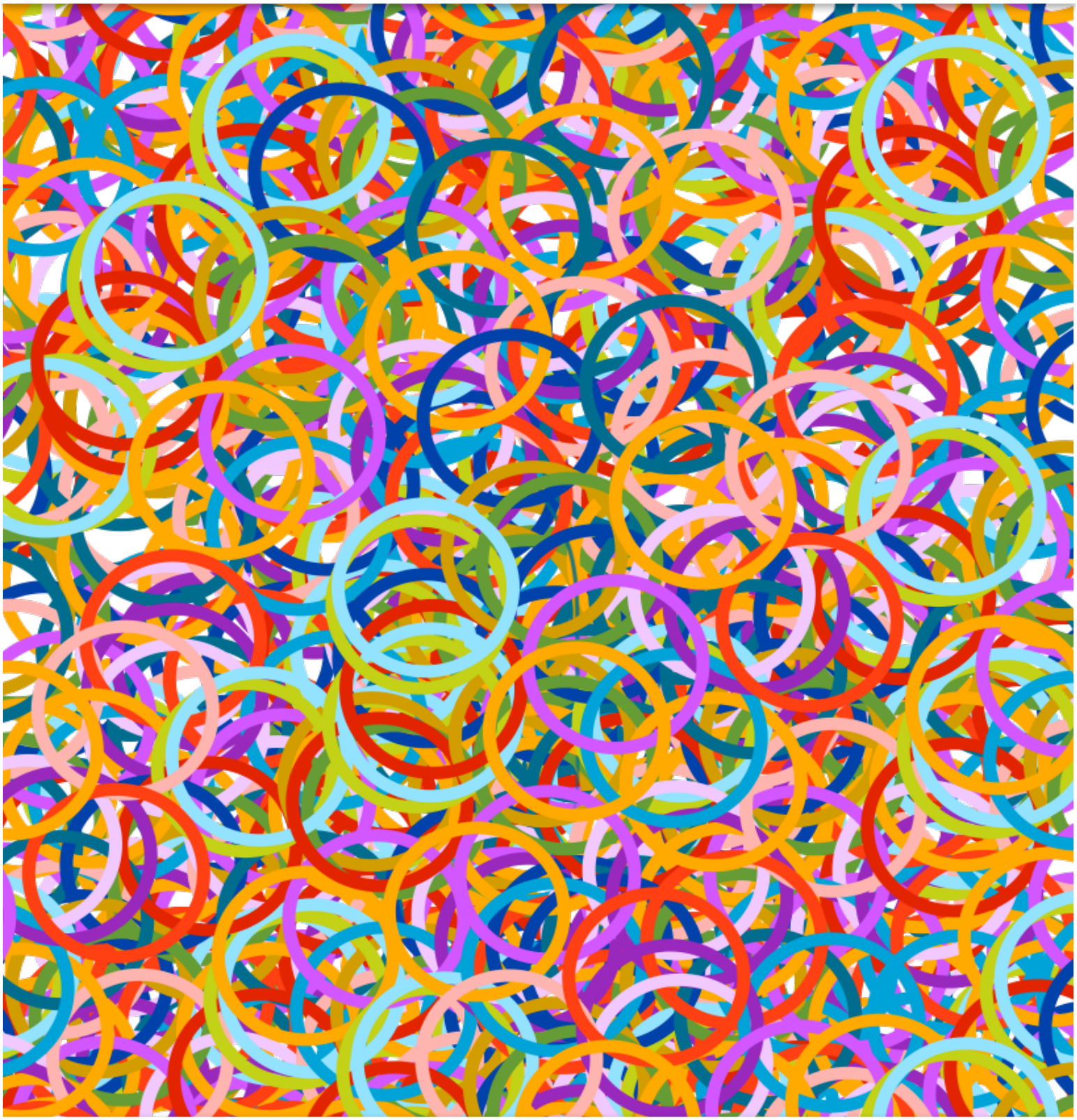

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Editorial

Connecting History and Foresight for Unprecedented Innovation Journeys

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> *"What all the successful entrepreneurs I have met have in common is not a certain kind of personality but a commitment to the systematic practice of innovation."*
>
> *"Innovation is the specific function of entrepreneurship, whether in an existing business, a public service institution, at a new venture started by a lone individual in the family kitchen."*
>
> *Peter Drucker*

It is common knowledge that history repeats itself! Maybe not literally, but patterns of behaviour likely dependent of the human nature, are probably prone to repeat themselves. So, one may wonder if looking back could help us prepare for a better future. Moreover, by looking back at the history of people and societies, we should all be able to have a better understanding of why things happen the way they do. This seldom happens, and when it does, it is happening within very limited circle of the society such as scholars and some politician circles, rarely overflowing to the whole society.

The point is that, what we see today is not very different from what has happened in the past. Let us go back to November 13, 1460, the day Prince Henry the Navigator, passed away in Sagres, leaving Portugal with an enormous debt. Despite that fact, Prince Henry was the "guiding force behind Portugal's assimilation of nautical knowledge and its vast extension of maritime exploration for nearly four decades" (Kock, 2003, p.59). It is interesting that by that time intellectual property was already being managed. After Prince Henry's death King Afonso V, "decreed that all discoveries derived from these explorations were the physical of intellectual property rights of Portugal alone, and henceforth to remain well-guarded and state secret" (Ibid., p.62). Along these endeavors, many innovations emerged, probably not known as "innovations", at the time. For example, the North Start was used to calculate the latitude in the northern hemisphere, however, as ships approached and crossed equator this star was no longer visible and they had to figure out a solution to determine their exact position in the southern hemisphere. To that end they devised "tables of declination based on the position of the sun as well as the formation of stars

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known as Southern Cross" (Ibid., p.62). This was just the beginning, but to make the long story short, Portugal was finally the first to reach the lands of the Indies by way of the sea! (Ibid., p.2).

The Portuguese discoveries reveal plenty of examples of much of what we today relate to entrepreneurship and innovation. In fact, the entrepreneur was there with a dream, and was able to engage everyone around him/her in the pursuance of that dream. There were also the investors, and those who did not believe it, as his own brother, "during his lifetime he [Prince Henry] often found himself the object of ridicule" (Ibid., p.59)!

As put by António Gedeão (Portuguese poet - lived from 1906 to 1997) in his poem "Pedra Filosofal" (Philosopher's stone):

"(…)	*"(…)*
Eles não sabem, nem sonham,	*They neither know, nor dream,*
que o sonho comanda a vida.	*that dreams command life.*
Que sempre que o homem sonha	*That whenever a man dreams*
o mundo pula e avança	*the world bounces and advances,*
como bola colorida	*like a coloured ball*
entre as mãos de uma criança."	*in the hands of a child."*

This is indeed not new, the power of dreams and the need for visionaries. It is, as well, a most interesting demonstration that innovation is not a one man/woman show and that innovation is spurred through collaboration!

Fast forward to the current days, and the perception of time is different. Each clock tic takes exactly the same time, but it somehow it seems faster, but why? We could have many explanations, the world economics would likely explain most of it, but people drive economics, at least they should, so, the question is what could we learn from the past? What could these teachings on innovation and entrepreneurship, not only from the Portuguese Discoveries but also from many other relevant and interesting experiences around the world, bring to today's entrepreneurs and innovators? We would like to challenge a combined effort of historians and innovators to seek cooperation and lend each other a helping hand!

"Historians have applied their method to a wider variety of subjects; regardless of the topic, historians ask questions, seek evidence, draw inferences from that evidence, create representations, and subject these representations to the scrutiny of other historians." (Staley, 2010, p.1). This is not so different from approaches used by other researchers, such as the ones working on the so-called Foresight. Foresight has been established as a tool to generate scenarios beyond the "reasonable"/expectable and foreseeable horizon, as an instrument for horizon scanning, as a structured approach to support decision making, and policy making. It self-embeds the notion of exploration, allowing unleashing opportunities, acting as a catalyst for mind opening activities. In itself, its application to design, sketch and define innovation strategies is

self-explanatory and undeniably rewarding. Yet, as of today, it is seldom used by innovators and we also call for futures and foresight experts to lend a helping hand to innovators!

We wish an enjoyable journey for historians, innovators and foresight researchers, working hands in hands in sketching and implementing enjoyable innovation journeys, leading to unprecedented discoveries!!

Innovatively Yours,

Anne-Laure Mention, João José Pinto Ferreira, Marko Torkkeli
Editors

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Cybersecurity - Personal Security Agents for People, Process, Atoms & Bits

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Letter from Academia

It was predicted by experts. The DDoS attack using an internet device on October 21, 2016, generated a flurry of suggestions from vast number of pundits. What if the attacks were not limited to social media sites but instead targeted heart monitors to deliver shocks to patients with cardiac arrhythmia? In this article the potential of personal security agents (PSA) is suggested as a modular tool to model people, process, bits and atoms (objects) with layers to address trust, privacy and security. Can we explore the potential of creating wrappers within these layers to include cognitive firewalls?

Keywords. Cybersecurity, agents, cognitive firewall, IPv6, IoT, healthcare.

1 A simple path – distributed trust management in cybersecurity?

The recent distributed denial of service (DDoS) attack originating from IoT type devices infected by the Mirai botnet[1] was predicted[2] by experts. The recent news about tracking individuals by name and location[3] to profit from advertisements was also perpetrated by experts. Objects and people appear to be equally vulnerable to cyber-intrusion.

The concept[4] of personal security agent (PSA) may not be novel and the idea of PSA may not be restricted to individuals. Devices may have PSA linked to a registry for example, GHR[5] maintained by CNRI[6]. Other less robust examples include mobile device management tool and rosy predictions[7] about MDM which are attracting new[8] entrants.

In light of revelations[9] which continues to accumulate, it is perhaps worth considering the security function (security-as-a-service) in layers where manufacturers of devices provides a layer of security but other independent layer(s) may be procured, installed and managed by the user, based on source(s) trusted, by the user.

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Perhaps, consider access to a secure box in a traditional bank vault which requires two keys to open. In its elemental form, this may be also viewed as a modular approach.

Let us extend this over-simplification to a traditional hotel room. The key card or mobile code to open the door may not allow the help to enter if the occupant dead-bolts or uses the security chain from inside. Imagine if neither the dead-bolt nor the security chain is made available to the hotel guest. The hotel advertises BYOD for security. On entering the hotel room or suite you find a bag of screws, a screw driver and four relevant holes on the door frame to insert and fix your own dead-bolt or chain. The digital equivalent (screws and holes) may be a *dynamic* API. The digital equivalent for dead-bolt (BYOD) is a digital certificate, with mobile duo authentication provided by a third party trusted vendor (of your choice).

2 A simple path – *Modus Operandi*

The suggestion involves the purchase of security-as-a-service (SECaaS) from a trusted vendor. This is, at this time, a hypothetical vendor. In the future it may manifest as a new line of business. SECaaS providers may include NGOs in the developing economies, government-academic-industry consortia, consumer watchdogs, global organizations or standards body (eg GS1, EAN, ITU[10], IEEE) which may not have a direct financial interest but offers an independent service for pay-per-use nano-fee-payment. The assumption is that an "external" agency removed from direct corporate influence is less likely to compromise security or squander privacy in line with their pedigree, credibility or brand recognition. Hence, we are more likely to trust their security-as-a-service (SECaaS) offer.

Vendors of devices (shop floor machines, healthcare robots, heart monitors[11], airplane turbines, valves for oil pipelines, refrigerators, automobile parts, prosthetics, phones) will offer APIs to digitally receive, install and activate the security service (SECaaS) layer. In future, devices which generate, transmit or acquire data may not be sold (FTC, FCC, FDA, UL type regulation) without APIs which may be deployed as an user-exit to install one or more layers (think containerization of the sand-box concept) of security protocols from one or more SECaaS providers, perhaps from different global regions.

Mobility makes it imperative that the security-as-a-service function is user controlled and calls for new software tools (CubeFog). The elements of this security may draw on a sub-tier of vendors specializing in offering a smorgasbord of dynamic security engines, for example, random number scheme, prime number cryptography, biometric coordinates.

Taken together, the management of trusted partners in the security-as-a-service ecosystem requires storage and connectivity with other domains (intruder detection, non-obvious relationship analysis, fraud monitoring). Data protection[12] rules and new policies[13] makes it essential for users to store and access their security-as-a-service data in their preferred nations and in clouds or fogs of their choice. Redundancies introduced by the user may make it difficult to penetrate all layers of security which did not originate from the device vendor or may not be hacked through the cloud storage.

3 A complex path – die is about IPSA

The device-linked PSA is one version of the personal security agent (PSA) for objects. But how an individual wishes to interact with the cyber-world and what data one wants to share or which information one chooses to keep private is inextricably linked to one's identity. Protecting this identity and keeping it secure is another function for the PSA. It helps to differentiate between object-PSA (OPSA) and individual-PSA (IPSA).

Starting with individual medical records[14] and continuing[15] to "DIE" promoted[16] by the World Bank and advocated[17] by GSMA, we must now deliver security and privacy at the level of individual citizens with a digital footprint based on their digital identity. The medium of delivery for IPSA is linked to OPSA because humans need a medium to interact with the cyber-world. *That* medium is provided by objects and may use various forms of IoT, by design, for industrial or consumer applications.

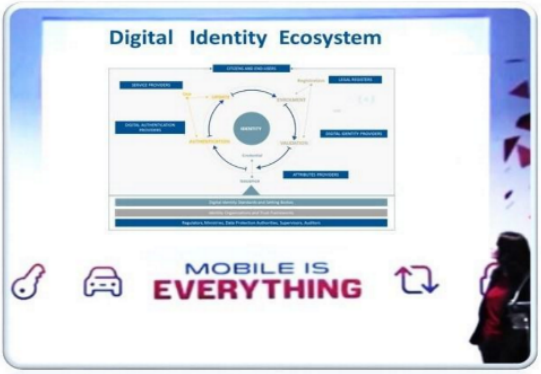

Fig. 1. The global momentum to endow each individual with a digital identity may be an appropriate vehicle to embed individual personal security agents (IPSA).

4 A complex path – *modus operandi*

There is very little debate to refute the need for national policy[18] and global tools. The latter must be redundant and distributed with very high fault tolerance. These tools must be capable of *ad hoc* dynamic composition when the *status quo* is challenged due to threats arising from breach of cybersecurity. Because *post hoc* security is useless in the IoT-by-design paradigm, the emphasis is on the dynamic composable architecture and its ability to "discover" atoms and bits in real-time related to the person or event.

IoT related cybersecurity may improve by implementing IPv6 which is the essence of connectivity. It is the fundamental routing layer in packet communications. The rapid diffusion of connectivity catalysed by IoT is increasingly inextricably linked with our lives and our digital twin[19] representations which includes information about information[20] may emerge as quintessential "avatars" to offer decision support.

Individual Personal Security Agents (IPSA) may protect privacy, regulate data sharing and communicate (including emergencies) between individuals and their digital world, which may include digital twins, in certain instances, especially for industrial systems.

IPSA must be globally unique and coupled with individual identification systems[21] eg social security number (USA) or Aadhaar (UIDAI, India). We propose a digital twin[22] approach handled by creating a mobile software intelligent agent for each citizen of the world (one may think of IPSA as an avatar popularized by "Second Life" games, 2003).

To tamper-proof the digital footprint and protect the digital records of this agent (IPSA) we may converge with tools from "blockchain" to document, authenticate and grant permissions to "handshake" for interoperability and multi-tasking across many diverse applications eg healthcare, banking, fintech, e-vote and remote 3D printing-on-demand. Using public key cryptography and personal agents to protect private keys, PSA may be equipped with tools to de-identify data in course of case-specific dynamic composition of responses. Hence, the potential to use IPSA in e-vote or sharing de-identified private data, for example, healthcare data collection, used for census or public policy surveys.

The agency of agents (APSA) acting on your behalf (IPSA) or on behalf of machine (OPSA) components or devices, associated with you, must be trained, updated and maintained to be in tune with your personal likes/dislikes/preferences for allowing or not allowing your data (location, medical data) to be shared (or not) when external agents or bots query your digital ecosystem. What if a mapping service queries your phone to share your location data? Who will protect you and offer privacy, if desired?

Your IPSA may be pre-programmed by you to respond according to your preferences which *you may change* using another remote device (OPSA) or modify associated dependencies using digital assistants (time of day, office or home, travelling for business or in clandestine meetings, medical status or trigger emergency *blue button*[23] over-ride). Perhaps similar approaches are necessary for Agents (OPSA) overseeing sensors, machine parts, medical devices, turbine blades, smart grids, automobile brake pads, water filters and trillions of non-human objects or things or processes using IoT as a digital by design metaphor.

APSA, IPSA, OPSA and other PSAs may be driven by standards. The road taken by trusted organizations may drive standards based operations for security-as-a-service to evolve.

However, standards or policies for every possible situation cannot be conceived *a priori*. Systems must be installed to trigger dynamic composition of *ad hoc* micro-directives[24]. Open data sharing may be as essential as selective de-identification schemes when anonymity and privacy are critical yet must be balanced in the best interest of the individual. For example, Sam collapses on the steps of Vittoriano[25] due to heat exhaustion and rushed to Ospedale Fatebenefratelli, nearby. But, they are unable to access her Epic-locked EHR from Massachusetts General Hospital. Sam is injected with a steroid and drifts to a comatose state. When staff in Rome speaks with Sam's physician in Cambridge, they learn that Sam is diabetic. Injecting steroid was a nail on her coffin.

In certain scenarios, IPSA and OPSA, if adequately tuned, may be a life saver. In other cases, the responses handled by the agents may be denuded of certain data or values to protect personal ID (convergence of public key encryption[26] with editable blockchain principles and IPv6 for mobile e-vote). Machines and devices (OPSA) may also want

data, information and metrics to remain cryptic to deter industrial espionage.

5 Why a Modular Approach may better optimize a dynamic connected path?

The ecosystem and/or community of PSAs must converge, connect and communicate to continuously monitor and curate diverse digital threads in order to synthesize the value and extract dividend from digital transformation.

The example of community as a *function* based on components as a *form* is a robust time-tested bio-inspired theme of modularity. One example of such a theme is anchored in the principles surrounding the evolution of nanobiomes with respect to life forms in the oceans[27]. Rather than combining all life functions into a single organism, the nano-biome works as a network of specialists, each with a special form (module), that can only exist as a community. The forms must converge in a spatio-temporal interplay to give rise to systemic interactions which, in turn, will manifest the desired function.

In the modular approach to cybersecurity, the form may be equivalent to agents, each specifically created to execute a particular task or role. When the agents aggregate to support a system, the overall outcome from convergence of these forms generates the function, in this case, the security of the system.

How do we determine that the individual agents and their related tasks are secure? This is where one begins to appreciate the value of modularity, convergence and the formation of agencies (groups of agents) which enhances the function (cybersecurity).

For example, you receive a message from your wife to warm up the lunch casserole for five minutes in the microwave. You proceed to perform this task and enjoy your lunch. What if you received a message from your wife to heat up the lunch for five hundred minutes in the microwave? You (the human) wouldn't comply with the command. Would you? Your sense of what is reasonable prevents the execution of the message and offers security. This action represents the concept[28] of a "cognitive" firewall which will raise an alarm based on what is reasonable (Joshua Eric Siegel, PhD thesis, MIT; Sanjay Sarma, personal communication).

Consider a simple command to a temperature sensor in a critical environment (cooling tower in a nuclear facility or combustion chamber in a jet engine or turbine). Usually, an external command may trigger the sensor to sense the temperature and report back to the data center every five minutes. An intruder-designed action or malware mimics the command but changes the time interval to five seconds. This action appears benign but the battery life of sensor may be depleted within a few hours. The sensor will cease to function.

If the temperature of the cooling tower or combustion chamber exceed the limits, it may result in a meltdown or some other form of catastrophe including loss of lives, injuries and contamination, due to failure of cybersecurity. The sensor and the micro-system functioned exactly in the manner it was designed - sense temperature on demand. But, the micro-system was not designed to reason that there may be a breach of security because the task demanded – sense and respond every five seconds – did not include

within its scope the validation process whether or not a particular command "makes sense" for the connected outcome and for the whole system.

A cognitive firewall and its "supervisor" function, if installed, as separate yet linked modules, could evaluate the system's process evolution and test incoming commands, to ensure that a particular command "makes sense" for the connected system. Supervisor may proactively monitor the system evolution and identify anomalous behavior due to system model breakdown, physical system failure, or other self-inflicted mechanisms.

Labelling this function as "cognitive" may invite justifiable criticism from scientists because the science of cognition is far more complex. Use of "cognition" is at best like using a new language without a dictionary or knowledge of grammar. It may be analogous to learning a language like a child - through imitation and trend identification in complex examples of linguistic usage. Similarly, claims of "intelligence" by corporate marketing departments are vapid, trite and shoddy if one considers the rigor of neural underpinnings of intelligence and compares them with the pedestrian apocalyptic momentum attributed to artificial intelligence[29] by those who may be biologically uninformed or inspired only by profit.

Connectivity of these forms and agents via IPv6 is one mechanism by which each entity level unit/model may communicate when the systems are distributed or where long range interactions are essential. One idea is rooted in the concept of *cube-on-cube* proposed by Marvin Minsky, MIT. See page 315 (Appendix: Brain Connections) from *Society of Mind* by Minsky (page 311 in this[30] PDF). The convergence of Marvin Minsky's cube-on-cube with connectivity between the cubes using IPv6 is a concept promoted by companies [31] professing that "containerization" as a software tool is an innovative new dimension.

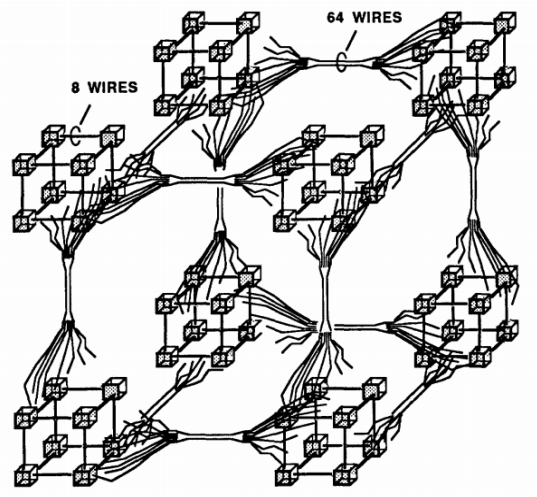

Fig. 2. Marvin Minsky's cube-on-cube concept [30] is extrapolated from and may be a representation of the topological connectivity between neurons or neuronal circuits.

Connectivity using IPv6 draws on an earlier (2006) proposal[32] advocating use of the internet protocol version six (IPv6) as a format to uniquely identify not only things (objects in the IoT) but also processes, relationships (syntax, semantics) and interfaces (sensors). The design key in the earlier paper (2006) relied on using the 128-bit IPv6 global standard which offers $3.4x10^{38}$ unique "names or addresses" to uniquely identify every instance of any transaction and follow their trail even when distributed (routed). By extrapolation, the 2006 paper appear to contain a few elements related to the concept[33] of blockchain[34] triggered[35] by the bitcoin principle[36] which highlights the principle of digital ledger. Implementing digital ledgers may monetize PSA but there aren't any low hanging fruits.

6 A path to monetization?

New business growth from security-as-a-service (cybersecurity software) may serve about 10 billion consumers by 2050 and trillions of B2B operations, much sooner. One must create and sell/lease/rent/train the Agents (IPSA, OPSA) for security-as-a-service.

Monetization of software for security-as-a-service (SECaaS) calls for innovation using the principles of the "digital ledger" to innovate a creative digital ledger practices.

The management of micro-payments from a pay-per-use model needs service request and service delivery documentation as well as QoS compliance. The trusted vendor must be dissociated from the service delivery once the service is activated, in order to reduce threat point of entry. The sales of the software license by the trusted vendor may not be the only transaction (in the old model a fixed payment was offered for a fixed term). If the trusted vendor wishes to charge by usage, then the ability of the trusted vendor to *monitor* the use of the service is pivotal. Dissociating the trusted vendor from keeping tabs on your security service is essential to improve security for the user. The latter introduces loss of opportunity for the trusted vendor because the vendor is in the dark about how many times the user is accessing the security-as-a-service (SECaaS) application.

Consider the camera on the front door of your house. You are in Princeton, NJ and your smartphone screen lights up. It shows FedEx Fiona walking up your driveway to deliver a package. Fiona rings the bell. You open the door to your home in Cambridge, MA while visiting Tom (you are in 203 Lewis Thomas Lab) using remote key pad on your Iris app connected to the Schlage digital lock on your door. Fiona goes inside the house. She exits from the house. The door locks behind her. You see Fiona walk down the drive.

What did FedEx Fiona do inside your home? You assume that she left the package on the table. What else did she do? Did she re-apply her lipstick? Did she use the toilet?

You wouldn't know what happened inside your home unless you have a camera inside. Trusted vendor for security-as-a-service needs the equivalent of a "camera outside" to know when you ping SECaaS. It chooses to remain oblivious of your use (what you accomplish). The latter would be the data from "camera inside" the house but trusted vendor is dissociated from that function. Trusted vendor does not need "inside" data because the trusted vendor charges micro-payments based on pay-per-use each time you ping the SECaaS app. It does not matter what you do but what matters is the

duration of the use (unit rate or cost) and the time of the day (traffic volume, bandwidth, latency may be factors in the quality of service or priority queue determination). Thus, the time-stamp is important for monetization and it is equivalent to house entry/exit data captured by the external camera. Privacy inside the house (data) remains unshared.

Distributed digital ledger, in practice, if combined with IPv6 transaction identity, can guarantee authenticity and auto-process time-based micro-payment for service delivery. Each unit of this distributed digital ledger is in the form of an agent module. The nature of the service can "drag and drop" the selected service units (modules) necessary to complete the function. The same modular principle which applies to each distributed task sub-unit is applicable in the distributed digital ledger paradigm. Concurrent execution, co-location and semantic interoperability between standards/platforms are key elements of this vision if we wish to transform the suggestions to implementations.

7 A path less travelled – the road not taken?

Returning to the discussion of cybersecurity, one wonders if these concepts threaded with IPv6 may be extended to propose a potential mechanism to improve cybersecurity by engineering design. Is there room for convergence between IPv6 and blockchain with selective use of public key encryption for digital object architecture[37] and IPSA?

How can we (can we?) use the 40 bits or an extension of the security domain in the current IPv6 design to serve as a cybersecurity base in the engineering design? Digital crypto-tokens concealed in the alphanumeric stretch may be connected with software security agents to authenticate (handshake) transactions, data transmissions or user activated action (the nature of which may be immensely diverse and vast in number).

The hypothetical concept of a set of *cascading locks*, is suggested. Only the header of the lock may be part of the 40-bit design of IPv6. Data related to the lock and its functional activation (I/O, open/close) may reside in a separate agent. It may mimic how RFID[38] EPC[39] contains a reference[40] to the location where the actual data[41] (or modular agent) is stored.

The locks may only open (allow, activate) with a digital key or digital token which must be generated in real-time (if triggered) using reference data (authentication?) secured by an agent in another location (potential for network verification at the edge).

The "open lock" status in tier-x could trigger the process to open the lock in tier-y (next lock in the cascade) using information (dependencies) from tier-x. This hypothetical cascade of locks and the sequential effect (outcome) may offer the ability to trap an intruder, in time. The system may sacrifice a few locks but eventually the aberration due to the intrusion or anomaly (if detected) can turn off the cascade (remaining locks, sequences in queue) to prevent the remaining steps (remaining locks are still locked). This is the type of function one may also expect from the supervisory layer of the cognitive firewall.

The hypothetical idea of cascading functions (with lagged dependency) is an attempt to theoretically propose protocols to prevent or contain an attack (intruder detection, repulsion, protection) if cascading functions were implemented (not known if it is

possible). If feasible and deployed, this system of security may be useful for autonomous transportation (prevent vehicle from being hacked) or machines (could prevent turning off turbine when a plane is in flight) or healthcare (prevent over-dose of morphine in post-operative surgical care) or energy grid brown-outs (time spoofing synchrophasor by creating anomalies in time-sensitive networking or causing protocols to malfunction).

8 Temporary conclusions

Being Digital[42] may not benefit from any hasty conclusions about people, bits and atoms surrounding cybersecurity. Questions will continue to accumulate and good answers may be few and far between. The patch work of solutions are not optimum but dreams of a final solution does not call for a dystopian or utopian classification. Those who may need to assign cybersecurity a category may wish to consider – what is being protopian?

Being protopian is balanced view and implementation of security and cybersecurity. Talking about security by design may be modified to security by engineering design to reflect that "baking" in security at the foundation is more robust than the after-thought of adding it to application layers, in many instances. The inclusion of PSA in the form of security as a service is not a common trend and may not gain momentum for some time.

The concept of agents may not have a mainstream following, yet, even though it is about 50 years old. One reason may be due to the obnoxious phrase "low hanging fruit" often used by the corporate world. Harvesting low hanging fruits require only low level skills.

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A Public Policy based on fiscal incentives for supporting companies to Invest in Innovation Projects – The Law of Good

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Policy Letter

Creativity, technical knowledge and financial resources, whether public or private, are three very important subjects to encourage technological innovation. Public policies on fiscal incentives fostering the increase of investment of financial resources for RD&I projects are particularly needed in developing countries. Therefore, this article aims to inform about the legal and bureaucratic procedures for the execution of research projects developed by partnerships between a company and an Institute of Science and Technology (i.e. ICT) applying the incentives of Brazilian Federal Law No. 11,196/2005 - Law of Good. This letter describes all the legislation that supports such incentives and outlines the needed accounting procedures to be performed. As a result, a demonstration on research expenditures and the impact on the reduction of income taxes is performed regarding to the following Brazilian income taxes: Income Tax (i.e. IRPJ) and Contribution on Net Income (i.e. CSLL), levied to the Brazilian taxpayers.

Keywords. Income tax, innovation, public policy, research and development, tax accounting.

1 The Law of Good

Public policies that can improve technological knowledge are necessary to increase competitiveness of developing countries. Particularly, tax incentive policies are necessary to increase investments in innovative technologies because the tax burden is very high, reducing the financial resources available to invest.

The Law of Good was created in 2005 to motivate Brazilian companies to invest in Research, Development and Innovation (i.e. RD&I). Such law has been increasingly used by companies that opt for the taxation called Real Income, which is the accounting calculation referring to the company financial results considering some criteria of the

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tax legislation. By 2012, more than 1,000 companies have qualified for the incentive which includes deductions from the Brazilian taxes called IRPJ (i.e. Income Tax) and CSLL (i.e. Social Contribution on Net Income), as well as differentiated rules for the depreciation of machinery and equipment.

1.1 Tax Incentives Regulation

The legislation that regulates the tax breaks for RD&I projects is described in the Law No. 11,196/2005, Chapter III, and the Decree No. 5,798/2006, and the Normative Instruction No. 1,187/2011 of the Brazilian Federal Internal Revenue Service (IRS).

Specifically, chapter III, articles 17 to 21, shows the fiscal incentives for technological innovation that companies must meet to obtain the benefits of the law, as follows:

- Art. 17. The corporate may take advantage of the following tax incentives:
  - I. Deduction, for purposes of determination of the net income, of the amount corresponding to the sum of the expenses with RD&I incurred during the determination period if classifiable as operating expenses by the tax legislation on income tax (i.e. IRPJ) or as payment defined in the paragraph 2 of this article;
  - II. Reduction of 50% (fifty percent) of the Tax on Industrialized Products (i.e. IPI) on equipment, machinery, electronic devices and instruments, as well as spare parts and tools accompanying such goods for RD&I projects;
  - III. Full depreciation of new machines, equipment, electronic devices and instruments, in related to the year of acquisition, intended for use in research activities and development of technological innovation, for purposes of calculating the IRPJ and CSLL;
  - IV. The accelerated amortization in the determination period, for purposes of calculating IRPJ, by deduction as an operating cost or expenses related to the acquisition of intangible assets, exclusively related to the activities of a RD&I project, classified in the deferred assets of the beneficiary.
- Art. 18. In accordance with Art. 17, paragraph 1, of this Law and with paragraph 6, the financial amounts transferred to microenterprises and small companies referred to in Law No. 9,841/1999, intended for the execution of RD&I projects of interest to the legal entity that paid the services may deduct the operating expenses, even if the legal entity receiving those amounts is interested in the economic results of the resulting product.
- Art. 19-A. The company may exclude from the net income the expenditures carried out in the RD&I project executed by a ICT, for purposes of calculating the income tax payable and for using as default value for calculating the CSLL (...).
- Art. 20. For the purposes of this Chapter, the amounts related to expenditures incurred in facilities and acquisition of electronic devices, machinery and equipment, intended for use in research and technological development projects, metrological tests, technical standardization and conformity assessment, applicable to products, processes, systems and personnel, authorization for registrations, licenses, homologations and their related forms, as well as procedures for the protection of intellectual property, may

be depreciated or amortized under current legislation, and the balance not depreciated or not amortized can be excluded in the determination of the income tax payable, in the determination period in which its use is completed.

- Art. 21. The federal government, through the agencies for funding science and technology, may subsidize the remuneration of researchers, both graduated and post-graduated, employed in activities of technological innovation in companies located in the Brazilian territory, using a specific regulation.

In addition, the company must meet the following requirements:

- be taxed under the Real Income regime;
- should have no debts with the Brazilian federal income taxation;
- should have reached taxable income in the period under consideration.

1.2 Accounting Procedures

Even more, there are difficulties to be faced by companies in relation to the accounting procedures of such fiscal incentives. For example, some difficulties were found in the execution of bureaucratic procedures to access the tax breaks when RD&I projects are submitted to the public calls of the Ministry of Science, Technology and Innovation (i.e. MCTI). Such calls invite interested parties to present RD&I projects involving scientific research and technological innovation aiming to promote and encourage developing innovative processes and products. In fact, researchers and companies find difficulties in understanding how resources used for research and innovation can be used to earn such fiscal incentives.

Therefore, we intend to unveil these procedures of Law No. 11,196 with a practical example that considers fictitious amounts to calculate what percentage can be deducted from the total taxable income.

2 Process procedures for obtaining the incentives for RD&I

Over time this law was better understood and, simultaneously, new institutions of science and technology (ICT) emerged in Brazil assuming an increasingly important role in RD&I projects. Consequently, it is particularly relevant that the Law of Good has motivated partnerships between ICTs and companies classified in the Real Income regime to carry out RD&I projects.

In the Law text, the government defined what an RD&I activity is by using the concepts of the Frascati Manual (OECD, 2013) which is a methodology for surveys on research and experimental development that intends to establish what is and what is not part of a RD&I project. Particularly, the Law characterize research projects as follows:

- Basic or fundamental research: consists of experimental or theoretical works carried out mainly with the aim of acquiring new knowledge about the fundamentals of observable phenomena and facts, without considering an existing application or specific use.
- Applied research: consists in the accomplishment of original works for purposes of acquiring new knowledge. It is primarily focused on a goal or specific

practical purpose.

- Experimental development: consists of performing systematic work, based on pre-existing knowledge, obtained through research and/or practical experience, to manufacture new materials, products or devices, processes, systems and services or to improve considerably the existing ones.

In summary, the Law defines technological innovation as the design of a new product or manufacturing process, as well as the aggregation of new functionalities or characteristics to the product or process that implies incremental improvements and effective gain of quality or productivity, resulting in greater competitiveness.

Companies should submit the RD&I project to CAPES - the government agency responsible for evaluating research programs in Brazil - so that it can be evaluated and then recommended if the evaluation criteria are fully satisfied, and then can use such tax incentives. This process is regulated by the Call for Proposals CAPES - MEC/MDIC/01/2007. This Public Call is an initiative to promote the research and development of innovative processes and products, with a view to public welfare, to the progress of science, to the country's technological autonomy, providing a strong link between the ICTs and companies. The main objective is to improve the national and regional business environment, as well as to stimulate the acquisition of industrial and intellectual property rights by ICTs and by national companies, by granting fiscal incentives to scientific and technological research projects. Additionally, another objective of this call is to better estimate or share costs, to reduce the technological risk of innovation and to stimulate an expansion of innovation activities in the Brazilian productive environment, as well as to prioritize proposals in line with the following actions of the Industrial, Technological and Foreign Trade Policy - PITCE:

- horizontal actions: increasing cooperation between ICTs and companies, increasing competitiveness through innovation, consolidation and promotion of technologies in the productive chains, reducing the cost of research and technological development activities;
- strategic options: semiconductors and software, drugs and medicines, and capital goods;
- new trends: biotechnology, nanotechnology, biomass and alternative energies.

The proposals are analyzed in two stages: (i) pre-qualification and (ii) evaluation of merit, within ninety days counted from the electronic submission. After this, the decisions of the Committee shall be published in the Official Gazette of the Brazilian Government, identifying the approved and rejected proposals for purposes of requesting reconsideration. In such a case, the Committee may appoint a new ad hoc consultant to support the assessment of the request for reconsideration, if appropriate.

After the publication of Ministerial Order, the corporate entity may exclude from the net income the expenses incurred to finance the RD&I project for the purposes of calculating the tax base of IRPJ and CSLL. It is noteworthy that it is only possible if the project was previously approved in accordance with the Art. 19-A, Law No. 11,196/2005 referred above, as well as the applicable tax regulations and the Public Call rules. The exclusion of expenses shall be carried out in accordance with the disbursement schedule provided for the execution of the project. The corporate entity is obliged to provide information to MCTI about its technological research programs

in accordance with the Ministry regulations by July 31 of the project ongoing year.

In addition, there are specific topics that are supported by the Law of Good, such as:

- Materials, supplies and services used for product improvements and manufacturing processes, including obtaining quality certificates;
- Expenses with salary and other labor costs related to employees or outsourced persons that perform activities related to RD&I;
- Actions to optimize the use of resources for the projects;
- Systems and software developed by the company itself or partially outsourced.

Then, once these tax breaks are authorized, companies are supposed to be prepared for the bureaucratic procedures that need to be well performed to get such tax incentives. Although the purposes and requirements defined in this law seem simple and clear, it turns out that bureaucratic procedures in Brazil are often quite complex and complicated due to a highly bureaucratic public administration.

3 A practical application of the Law of Good

In general, the taxation in the Real Income regime applies to: (i) large companies, (ii) certain segments of the economy which use fiscal incentives, (iii) companies that carry out operations in foreign trade and (iv) companies that are bound by tax legislation to this type of taxation.

In the following paragraphs, a simple exercise for a tax accounting case related to a RD&I project between a company and a ITC is presented. The objective is to determine the tax payable when two situations are considered, when the Law of Good is applied and when it is not. Taxable income is the net income for the period adjusted by additions, exclusions or prescribed compensation or those authorized by Regulation (Decree Law 1,598 / 1977, Article 6).

The exercise is based on the following questions. Whereas a company decided to hire an ICT to conduct a RD&I project approved by CAPES within the public call referred to in previous chapter, with an annual expenditure of the project to a value of U$ 1,000,000.00 (fictitious value), how can the income tax be calculated by using tax incentive requirements and what would be the amount of the deductions in relation to the taxes payable?

In continuing the exercise, the gross margin of U$50,000,000.00 was obtained subtracting from the gross revenue the costs of sales. The next step is to determine the net income by subtracting the operating and administrative costs, adding to the non-deductible expenses. However, in aiming to determine the net income in case in which the company uses the tax incentives of the Law of Good the expenses with the RD&I project are then subtracted, differently of trivial cases.

In this exercise, the amounts used are the following: A) the gross margin of the company is U$50,000,000.00; B) operational and administrative costs are U$36,500,000.00; C) non-deductible expenses are U$100,000.00; and D) the amount contributed to the RD&I project is U$ 1,000,000.00. The calculation of the net income (NI) differently for both situations (i.e. with and without the Law of Good) is derived of the formulas described as follows:

- Using Law of Good:

$NI_{LG} = A – B + C - D.$	(**1**)

- Not using Law of Good:

$NI_{T} = A – B + C.$	(**2**)

As result, by using the Law of Good, the value considered of the net income is $12,5 million, it is unlike in case of non-use of tax incentives in which the considered net income becoming $13,5 million.

The next step adjustments are made for calculating the net income value by using the IRS regulation. Applying the Law of Good, some topics such as: D) in expenses, donations, distribution of profits and other requirements are added, making in this exercise the amount of $1,155,000.00, including also E) the financial contribution to the RD&I project. However, in case of using tax incentives, the expenses with the project are then subtracted, but this does not occur when the Law of Good is not used. Thus, the value of the taxable income is calculated in the period considered.

The calculation of taxable income (IT) for both situations, when the Law of Good is used and when not used, derives from the formulas described as follows:

- Using Law of Good:

$TI_{LG} = NI_{LG} + D + E - E.$	(**3**)

- Not using Law of Good:

$TI_{T} = NI_{T} + D + E.$	(**4**)

In this case, with the Law of Good being applied, the value of the taxable income is $13,655 million. However, in case of non-use of tax incentives the taxable income is $14,630 million.

Following, after determining the taxable income then the Brazilian taxes payable can be determined. It starts with the calculation of the amount of the income tax (IRPJ) to be paid differently for both situations referred above that being derives of the formulas described as follows, and a rate of 15% is used:

- Using Law of Good:

$IRPJ_{LG} = TI_{LG} \times 0,15$	(**5**)

- Not using Law of Good:

$IRPJ_{T} = TI_{T} \times 0,15$	(**6**)

Thus, by using the Law of Good, the value of the IRPJ tax is $2,048,250.00, on the

contrary in case of non-use of tax incentives the IRPJ tax is $2.194,500.00.

In sequence, according to the IRS regulation the IRPJ tax has an additional amount when the profit value exceeds the value of R$20,000.00 (approximately $6,000.00). That is, this amount should be added in relation to the twelve months of the year, multiplying by 12 and then applying a rate of 10%. In fact, this value must be subtracted of the taxable income previously determined.

The calculation of the IRPJ Additional tax to be paid differently for both situations is derived of the formula described as follows:

- Using Law of Good:

$$IRPJ_{LG}\ Additional = (TI_{LG} - (12 \times 6{,}000.00)) \times 0{,}1 \quad (7)$$

- Not using Law of Good:

$$IRPJ_{T}\ Additional = (TI_{T} - (12 \times 6{,}000.00)) \times 0{,}1 \quad (8)$$

This time, using the Law of Good, the value of the IRPJ Additional tax is $1,341,500.00, differently in case of non-use of tax incentives then the IRPJ Additional is $1.439,000.00.

Combining both amounts then the IRPJ reached the value of $3,389,770.00 in case of the use of Law of Good, on the other hand in case of non-use of tax incentives then the IRPJ tax is $3.663,500.00. That is, less $273,730.00 due to the tax incentive for RD&I projects.

In addition, the CSLL tax is calculated in a simple way, by using a rate of 9%. The calculation of the tax amount to be paid differently for both situations is derived of the formulas described as follows:

- Using Law of Good:

$$CSLL_{LG} = TI_{LG} \times 0{,}09 \quad (9)$$

- Not using Law of Good:

$$CSLL_{T} = TI_{T} \times 0{,}09 \quad (10)$$

Therefore, using the Law of Good, the value of the CSLL tax is $1,228,850.00, it is unlike in the case of non-use of the tax incentives, the CSLL tax is $1.316,700.00. That is, less $ 87,850.00 due to the tax incentive for RD&I projects.

After all these calculations, the amount saved when using the Law of Good is $243,750.00 for the $IRPJ_{LG}$ and $87,750.00 for the $CSLL_{LG}$, totaling $331,500.00 less in taxes payable. This means 33.15% benefit over the amount applied in the RD&I project. On the other side, it is possible to say that the government pays about one-third of the RD&I project.

Furthermore, in accordance with various simulations for various business real-life situations surveyed, the benefit that can be achieved is between 20.4% to 34%, and so

this becomes really motivating for companies to use such tax incentives.

4 Conclusions

This letter intended to inform about the relationship between ICTs and companies regarding the application of Law No. 11.196 / 2005, the Law of Good, and to present a practical example regarding booking of expenditure on which was calculated the percentage of tax exemption to which companies can be benefited.

Indeed, by applying this law it was verified that a significant percentage of tax exemption can be obtained, thus motivating companies to perform RD&I projects, including partnership with public and private ICTs.

Although the accounting procedures performed by companies are more complex than this letter shows, the results was presented in a simple form aiming to demonstrate the utility of such regulation for obtaining tax incentives.

In fact, the Brazilian government has continuously updated laws that improve legislation to motivate research activities and the development of technological innovation. It is noteworthy that recently the regulatory framework concerning Brazilian science and technology environment has been created to complement an existing set of regulations to encourage companies to perform RD&I projects.

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Front End of Innovation: An Integrative Literature Review

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Abstract. The beginning of the innovation process also known as Front End of Innovation (FEI) is an important contributor to the successful development of new products and the business success. The present study aims at giving an overview of how the FEI concept has been handled over the years, by identifying the focus of the research conducted in this domain knowledge. To this end, this study unfolds an encompassing perspective by developing an analysis of existing publications against two FEI Reference Models. This analysis comprised of the compilation, selection, and review of the content of 169 publications concerning the Front End of Innovation. The period of analysis covered all years until 2015. Evidence shows that this topic has received greater attention in the recent years both regarding depth and the number of publications. However, there are still pending gaps in the literature that are highlighted in this paper. The topics addressing organisational issues were the ones that received more attention.

Keywords. Innovation, Front-End of Innovation, FEI, Integrative Literature Review.

1 Introduction

Despite considerable investment in New Product Development (NPD), success rates of NPD are generally below 25% (Evanschitzky et al., 2012). Any firm aiming at competing on innovation needs to be proficient in all phases of the NPD process (Khurana and Rosenthal, 1998). This process is typically divided into three phases: The Fuzzy Front End (FFE) ending with the so-called Concept Development, the New Product Development (NPD) process and the Commercialization (Koen et al., 2002). FFE is also known as Front End of Innovation (Martinsuo and Poskela, 2011). In this paper, we will use this term.

The early phase of innovation requires attention since it is recognised as an important driver of positive results for new products and for the overall success of the business (Kock et al., 2015). In his paper on the impact of front-end innovation activities on product performance, Markham shows that the Front-end success is the strongest independent predictor of all of the NPD performance

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variables. He further shows how the first stages of the innovation process are critical because the front-end performance impacts product success, time to market, market penetration, and financial performance (Markham, 2013).

In this context that stresses the relevance of the FEI, this review aims at providing an overview about how the FEI concept has been unfolding over the years by identifying the focus of the research conducted in this domain knowledge. We follow the integrative literature review approach as defined byTorraco, as "a form of research that reviews, critiques, and synthesizes representative literature on a topic in an integrated way such that new frameworks and perspectives on the topic are generated."(Torraco, 2005, p.356). As a result, this integrative literature review shows the diversity and depth of the topics approached in this field. The goal is to demonstrate that the FEI literature remains highly dispersed (Eliens and May, 2015) and that the FEI is comparatively less studied than the NPD and Commercialization phases (Koen et al., 2014).

This study offers an encompassing perspective by building on two FEI Reference Models. The analysis is based on the compilation, selection, and review of the content of 169 publications concerning the Front end of Innovation. The search included all papers published in SCOPUS until the end of 2015.

The analysis followed a framework that integrates two theoretical models, the so-called "New Concept Development Model" proposed by (Koen et al., 2002) and the "Three Phase Front End Model" proposed by (Khurana and Rosenthal, 1997, 1998).

The paper is organised into six sections. Following the introduction laid down under Section 1, section 2 offers a brief overview of the literature on the topic of the FEI. The research method is presented in Section 3, followed by the presentation of results in Section 4 and their discussion with the concluding remarks in Section 5. Section 6 tackles the limitations of the work.

2 Literature review

Innovation is an important issue for organisations and countries. Technological Innovation has a disruptive character that promotes differentiation for organisations, which may enable them to have a distinctive position in the competitive market (Schumpeter, 1988). It is worth pointing out that when we think about technology, we look at it as a means that can be used to accomplish a certain end (Eckhardt, 2013).

In fact, there are studies which suggest that innovation may lead organisations to a prominent position (Banbury and Michell, 1995). In this context, new products play an important role, as they may generate new revenues and new markets (Tidd et al., 2008).

Innovation stems from ideas that are the result of a creative or rational thinking process. This process may have the involvement of several actors, such as employees, customers, suppliers or universities organised as individuals or groups (Boeddrich, 2004). Moreover, innovation is a concept that depicts not only something that is new but also that is economically viable, technically feasible and expected to be successful in the market (Mueller and Thoring, 2012).

Innovation management plays, therefore, an important role in companies seeking to find innovative products and business opportunities. This importance is, indeed, about learning how to find the solution that best suits the problem of turning ideas into a successful reality. Within specific organisational circumstances, organisations will always strive to do it the best possible way (Bessant, 2003).

FEI activities play, thus, a very important role in this process, as they may provide value and increase the amount and probability of success of the developed concepts aiming at future commercialization (Koen et al., 2002). The in-depth understanding of the Front End of Innovation can be seen as the ideal starting point for innovation, as FEI can foster the coordinated process of product or service concept development (Wagner, 2012).

Research shows that FEI optimization and improvement lead organizations to positive results by increasing chances of development of innovation (Boeddrich, 2004; Koen et al., 2014; Koen et al., 2014a; Markham, 2013; Stevens and Burley, 2004; Verworn et al., 2008; Williams et al., 2007).

Activities carried out in the FEI have a distinctive nature, being both experimental and often chaotic. In contrast, the NPD stage is more focused, disciplined and goal-orientated with a well-defined project plan (Koen et al., 2002). Montoya-Weiss and O´ Driscoll (2000) refer to FFE (FEI) as unstructured and Ad-Hoc. Despite the "fuzziness" of this stage, the FEI is the foundation for the generation of successful New Product Development (NPD) (Martinsuo and Poskela, 2011).

FEI also brings about some challenges. Some authors highlight significant different approaches to FEI for promoting radical and incremental innovations in NPD projects (Reid and De Brentani, 2004). More recent work argues that there are no significant differences (Verworn et al., 2008). Another debate concerns the benefits of adopting a structured versus a non-structured approach for the FEI process. Recent research has shown the benefit of intensive initial planning and the process-oriented approach (Verworn et al., 2008; Markham, 2013). The literature review has further unveiled that most published works looking into FEI models and frameworks, include the four references highlighted in Table.

Table 1. FEI Reference works.

Year	Authors	Focus
1993	Cooper, R. G.	This work aims at a successful product innovation process, from idea to launch. The first phases represent the FEI and make use of stage-gates.
1997	Khurana, A. Rosenthal, S. R.	It is a front-end approach that links business and product strategy with product-specific decisions.
2001	Koen et al.	The aim of the work was to provide methods, tools, and techniques suitable for managing the Front End of Innovation. Furthermore, the authors envisioned the possibility of specifying a vision and a common terminology for FEI.
2004	Reid, S. E. De Brentani, U.	Focus on disruptive innovation. A scheme based on the idea of a reversed information flow from the outside world toward the organisation. Individuals who play important roles facilitate this flow. The first interface is known as "boundary interface," followed by the "gatekeeping interface" and concluded with the project interface.

For Gaubinger and Rabl (2013) the four models most frequently cited in FEI literature are the "Stage Gate process" (Cooper, 1993); the "Three Phase Front End Model" (Khurana and Rosenthal, 1997); and the "New Concept Development Model" (Koen et al., 2002). Therefore, it can be said that the overview presented under Table 1 is by no means comprehensive; however, it does list important and seminal contributions to the conceptualization of the FEI. The next few paragraphs will briefly go through each one of these papers.

An important contribution from the Cooper´s model (1993) regards the Concept Test occurring before the final assessment, thus representing the anticipation of important decisions. This model has received improvements over the time through the integration of both lean and agile approaches. The proposed Stage-gate process "consists of a set of information-gathering stages followed by go/kill decision gates" (Cooper, 2008, p. 214).

The paper "Integrating the Fuzzy Front End of New Product Development" by (Khurana and Rosenthal, 1997) identifies the important role organisational strategy plays as a driving force in the innovation process. The authors propose a model focused on the linkage between business and product strategy. Moreover, they emphasise the importance of a well-planned portfolio; the existence of an enabling organisational structure; the need to adequately identify customer needs; and the development of a well-defined product concept as a means for a successful NPD.

There is an important contribution from Koen et al. (2002) with the New Concept Development Model. The aim of the work was to provide methods, tools, and techniques suitable for managing the FEI, although, these tools are likely to be selected and used in a heuristic manner (Achiche et al., 2013). The "NCD Model" proposed by Koen et al. (2002) is composed of three important parts, namely: The Engine, the Controllable Activity Elements, and the Influencing Factors. The first one is related to aspects such as Leadership, Culture and Business Strategy. The Key Elements (inner parts of the model) comprise the Opportunity Identification, the Opportunity Analysis, the Idea Generation and Enrichment, the Idea Selection, and the Concept Definition. At last, the influencing factors are those related to the internal and external environment, namely Organizational Capabilities and the Outside World. According to the authors, all these factors may influence the entire innovation process from the very beginning until the final commercialization phase.

The models proposed by Cooper (1988) and by Khurana and Rosenthal (1997) are linear schemes. Over the years, the Cooper´s model has evolved and has gained an iterative nature. In turn, Koen et al. (2002) designed a model with a nature that is fundamentally iterative, trying to address the complexity of this phase.

In the last row of the table, Reid and De Brentani (2004) have been focusing on FEI for radical innovations. As a result, they have proposed a model that aims at dealing with risk more effectively and considering the complexity that arises in disruptive innovations. Their proposal has a major focus on decision-making points. This emphasis on decision making is valuable for organisations, as it provides a configuration that helps the flow of information, regarding the development of a new product. This theoretical model has received contributions and enhancements (De Brentani and Reid, 2012).

These are seminal works focusing on the early stages of the innovation process. They aim at providing efficiency and efficacy for the FEI. Although valuable contributions have been made so far, there is still room for contributions to this domain of knowledge.

3 Research method

This research follows the so-called Integrative Literature Review Approach (Torraco, 2005). This strategy "is a form of a research that reviews, critiques, and synthesizes the representative literature on a topic in an integrated way so that new frameworks and perspectives on the topic are generated" (Torraco, 2005, p, 356). In other words, an integrative literature review for the FEI allows a summarised review of the topic, provides the means to draw a comprehensive picture of what has been studied so far in the scope of this theme, thus contributing to a consolidated and systematic overview of the area.

3.1 Data collection procedures

The data collection process was carried out from the Scopus database, a recognised multidisciplinary scientific database. In what concerns the choice of a database, as both Scopus and Web of Science offer quite similar functionalities and coverage (Öchsner, 2013), Scopus was chosen since this database exhibited the greatest number of active titles in February of 2014 (Scopus, 2014).

The search included papers published up to 2015. After the classification protocol was put in place, relevant works were found only from 1995 onwards. Results published before 1995 although being considered due to the use of the pair words "Front End" and "Innovation" addressed other contexts, not the management of the predevelopment phase of the innovation process. This search was conducted for the predefined subject areas listed by Scopus as follows:

> Business, Management, and Accounting; Engineering; Computer Science; Decision Sciences; Economics, Econometrics, and Finance; Social Science; Material Science; Arts and Humanities; and, Psychology.

The following areas were excluded from the query:

> Energy; Medicine; Chemical Engineering; Physics and Astronomy; Agricultural and Biological Science; Environmental Science; Chemistry; Earth and Planetary Sciences; Biochemistry, Genetics, and Molecular Biology; Health Professions; Nursing; Pharmacology, Toxicology, and Pharmaceutics; Immunology and Microbiology; Mathematics; and, Neuroscience.

The search has only considered documents classified as "article." This was done to ensure that all selected works have gone through a peer review process. The database query was made using the following type of field: "Article Title, Abstract, and Keyword." To widen the results of the query the proximity indicator filter was used. For instance, W/n "within." In this case, the query was set up as follows:

> "Front end" of W/8 innovation

The proximity indicator searches for "innovation" within the following eight

words in the text. This search configuration leads to a result with a larger number of selected articles related to the research goal.

Figure 1 illustrates the reason why the expression "front end" was used among other possible denominations for this concept. The amount of results found explains that the term "front end" is widely used, as compared with other possible formulations.

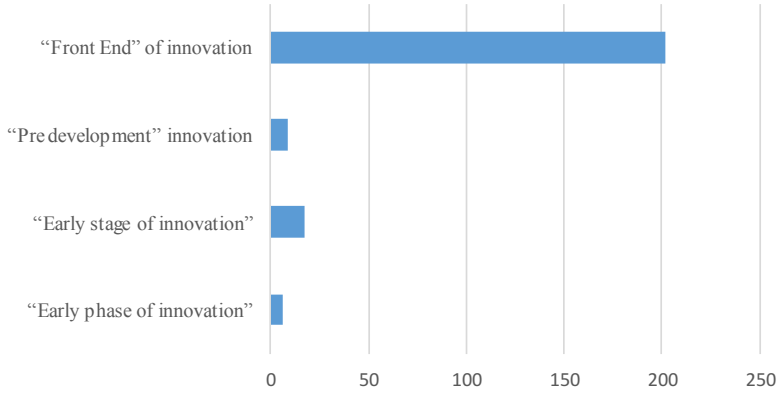

Fig. 1. Results found concerning the possible nomenclatures to be used in the query.

The term "Fuzzy Front End" is contemplated in the use of the expression "Front End." Moreover, the Scopus database makes no difference in what regards the use of hyphen for "front-end" or "front end."

The authors have classified the works according to their contents. Search results were further analysed and classified to select only those papers dealing with topics related to the FEI. In some papers, the expression "Front End (…) Innovation" was not related to FEI but to other issues such as topics addressing the role of design, organisational Front End activities, and Front End engineering concepts. Additionally, papers with no abstract or written in a language other than English were not considered. After the classification procedures, in the final sample includes a total of 169 titles.

3.2 Data collection

The theoretical framework for analysing the results was based on the model proposed by Koen et al. (2002) "New Concept Development" (NCD) (Figure 2). This approach was chosen as this is the method accepted and used by the Product Development Management Association. For the sake of providing an additional perspective of analysis, the findings were also plotted into the "Three Phase Front End Model" (Khurana and Rosenthal, 1997, 1998). This model was selected as it provides a wide perspective on the FEI processes while keeping the same definition for "idea" and "opportunity" as the NCD Model.

The 169 articles were organised in an electronic spreadsheet. They were systematically organised according to their publication year, title, abstract and publication information. The results were categorised taking into consideration the contents in the abstract. The content of each paper was plotted into an n-dimensional classification space featuring components of two frameworks: the

"NCD Model"; and the "Three Phase Front End Model." It must be stressed that some papers could be classified under more than one category. These cases were classified considering the dominant approach put forward by the work. For example: a research publication on the "process of generating new-market disruptive innovation (NDI) ideas for products, driven by design and resources" would be classified as "Idea Generation and Enrichment" (IGE) in the "NCD Model". Moreover, as "Pre-phase Zero" (PP0) in the "The Three Phase Front End Model". However, it could have been classified as well into "Organisational Capabilities" (OC) / "Product Development Organization" (PDO) respectively in the two reference models.

Out of the total 169 articles, 44 papers offered contributions for the FEI regarded as a framework, a model, a process, a tool or even a methodology.

The analytical categories used in this research are shown in Figures 2 and 3.

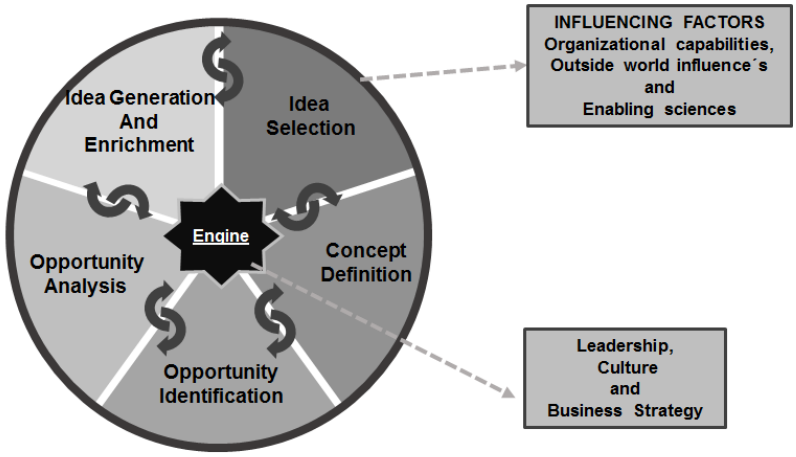

Fig. 2. NCD Model as categories of analysis – Adapted from Koen et al. (2002)

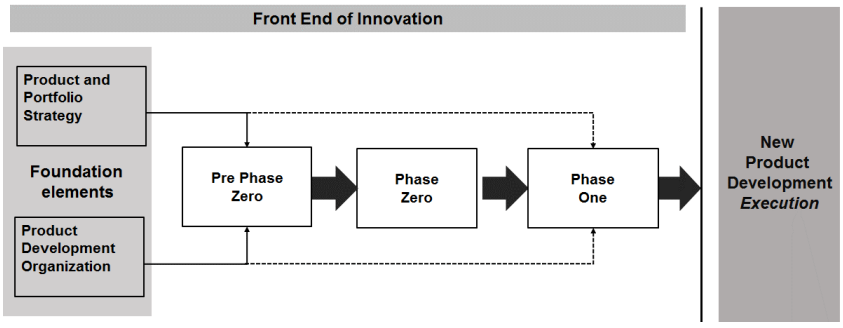

Fig. 3. Three Phase Model of the Front End of Innovation as categories of analysis – Adapted from Khurana and Rosenthal (1998)

The coding for the categories of analysis used in the classification protocols is illustrated in Table 2. The acronyms listed below will be used in the classification tables in the following section.

Table 2. List of acronyms used for the categories of analysis

NCD Model	ACRONYMS
Leadership	LD
Culture	CULT
Business Strategy	BS
Idea Generation and Enrichment	IGE
Idea Selection	IS
Opportunity Identification	OI
Opportunity Analysis	OA
Concept Definition	CD
Organizational Capabilities	OC
Outside World Influence´s (Customer and competitor influences)	OWI
Enabling Sciences	EST
The Three Phase model of the Front End of Innovation	
Product and Portfolio Strategy - PPS	PPS
Product Development Organization (Structure, Roles, Incentives and Norms)	PDO
Pre-phase zero (Preliminary Opportunity Identification, Idea Generation, Market and Technology Analysis)	PP0
Phase zero (Product Concept and Definition)	P0
Phase one (Feasibility and Project Planning)	P1

4 Results

The analysis shows that increasing attention has been paid to the FEI in recent years. The term "Fuzzy Front End" was coined at the beginning of the nineties, but it has only started to be considered as a consistently increasing trend in the field since 2006. 2012 was identified as the year with the highest number of publications, as illustrated in Figure 4.

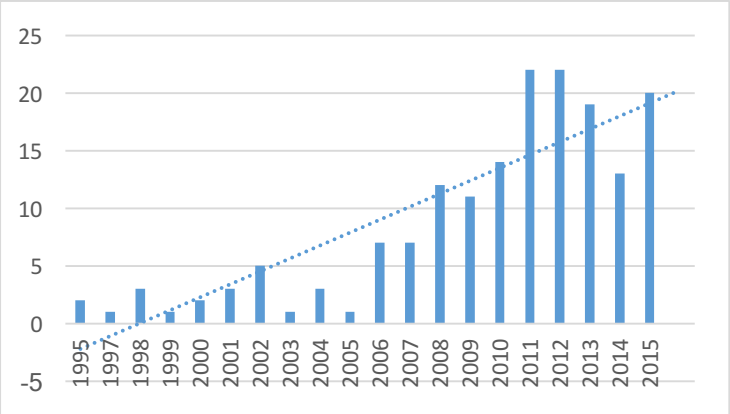

Fig. 4. FEI works from 1995 to 2015

Figure 4 illustrates the trend of the 169 publications along the years, depicting a growing number of published papers in this domain of knowledge. It should be noted that this analysis makes no distinction between the type of innovation (incremental or radical) discussed in each paper.

4.1 Analysis Projected over the NCD Model

The multidisciplinary nature of this field of knowledge leads to a scenario where one has a broad number of research topics, some recurrent in many papers, and other topics receiving less attention. Table 3 displays the number of publications per year (line) and per research topic (column).

Table 3. Incidence of NCD Model´s elements addressed per year from 1995-2015

Year	BS	CD	CULT	EST	IGE	IS	LD	OA	OC	OI	OW	Total
1995					1				1			**2**
1997			1									**1**
1998					1				2			**3**
1999									1			**1**
2000				1					1			**2**
2001	1							1	1			**3**
2002				1	1				3			**5**
2003									1			**1**
2004									3			**3**
2006	1	2							3	1		**7**
2007	1	3							1	2		**7**
2008	1	3			3			1	3	1		**12**
2009	2	4		1	1			1	1		1	**11**
2010	2	2			2			1	4	2	1	**14**
2011	4	3	1		3	1			6	2	2	**22**
2012	3	1	1		6	1		1	6	2	1	**22**
2013	1	6	1		6		1	1	1	2		**19**
2014					4				6	2	1	**13**
2015	1	1		1	5				8	4		**20**
Total	**17**	**25**	**4**	**4**	**33**	**2**	**1**	**6**	**53**	**18**	**6**	**169**

Although the number of papers has been increasing over time, topics such as Leadership, Idea Selection, Enabling Sciences and Culture have only received limited attention. As illustrated, the findings suggest that some areas have received more attention in quantitative terms. Such is the case of OC – Organisational Capabilities. OC represents a big umbrella, covering topics varying from structure, resources, capabilities and competencies to processes, norms and efficiency, which may partly explain its high number of hits. Idea Generation and Enrichment (IGE) is also quite encompassing, as it includes: the means, incentives, methods, tools, techniques and resources used for IGE activities.

Another topic that received important contributions is the CD – Concept Definition. This activity involves an important task in the process, as it represents the input for the New Product Development and Commercialization phases.

It is now relevant to consider the structure of the NCD Model to analyse the results. Table 4 shows the configuration of the NCD building on the definitions proposed by Koen et al. (2002). In this context, results show that:

- More attention was given to the OC – Organisational Capabilities, which is part of the Influencing Factors in the NCD Model.
- Controllable Activities are receiving a broader attention in FEI publications (related to topics such as Idea Generation and Enrichment, Concept Definition and Opportunity Identification).

Table 4. NCD Model´s composition

Part of the Model	Content addressed
Engine	Leadership – LD
	Culture – CULT
	Business Strategy – BS
Elements (Controllable Activities)	Idea Generation and Enrichment – IGE
	Idea Selection – IS
	Opportunity Identification – OI
	Opportunity Analysis - OA
	Concept Definition - CD
Influencing Factors	Organisational Capabilities - OC
	Outside World Influence´s – OW
	Enabling Sciences and Technologies -EST

The part of the model that has received less attention regarding the number of publications was the Engine, addressing topics such as Leadership, Culture and Business Strategy. The relevance of these topics however has been addressed in a recent study (Koen, Bertels, and Kleinschmidt, 2014) where 197 empirical cases on successful Front End practices were analysed. The study highlighted the importance of senior management commitment, vision, strategy, and resources.

As the major contribution regarding the volume of publications is from 2006, Figure 5 illustrates the inner parts of the "NCD Model" showing the number of publications over the last years.

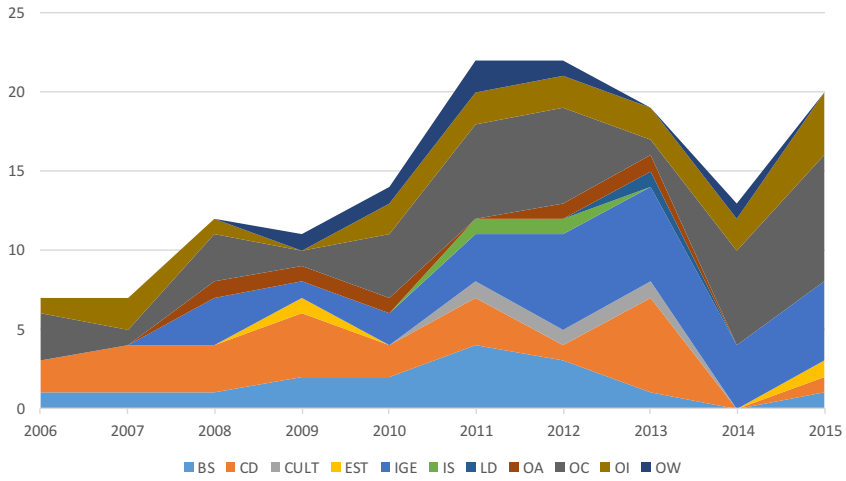

Fig. 5. Inner parts of the NCD Model addressed per year, 2006 - 2015

4.2 Analysis Projected over the Three Phase Front End Model

In order to provide a comparative visualisation of the analysed data, the 169 papers were also classified following the framework of analysis proposed by Khurana and Rosenthal (1998). In this approach, the FEI activities include product strategy formulation and communication, opportunity identification and assessment, idea generation, product definition, project planning and executive reviews. The "Three Phase Front End Model" (Khurana and Rosenthal, 1997, 1998) is organised as illustrated in Table 5.

Table 5. The Three Phase Front End Model

Concept	Responsibilities
Foundation Elements	Product and Portfolio Strategy - PPS
	Product Development Organization - PDO
Front End	Pre-phase zero (Preliminary Opportunity Identification, Market and Technology Analysis) – PP0
	Phase zero (Product Concept and Definition) – P0
	Phase one (Feasibility and Project Planning) – P1

This model emphasises the organisational alignment and the product strategy. The authors further highlight the great value of the interrelationship between activities, which are considered as important as the activities themselves (Khurana and Rosenthal, 1997). Taking into account this framework of analysis, the result of the analysis of the 169 papers is shown in Table 6.

Table 6. Finding results according to the Three Phase Front End Model

Year	P0	P1	PDO	PP0	PPS	Total
1995			1	1		2
1997			1			1
1998			2	1		3
1999		1				1
2000			1		1	2
2001			1	1	1	3
2002			3	2		5
2003			1			1
2004			3			3
2005			1			1
2006	2	2	2		1	7
2007	2	1	1	2	1	7
2008		3	2	5	2	12
2009	2	4		2	3	11
2010	1		5	5	3	14
2011	3	2	8	4	5	22
2012	2		9	9	2	22
2013	6		7	6		19
2014	1	4	5	3		13
2015	4	4	5	6	1	20
Total	**23**	**21**	**59**	**47**	**20**	**169**

Based on these results we can state that the parts of the model that have received more attention from 1995 to 2015 were respectively PDO (Product Development Organization) and PP0 (Pre-phase zero). The Product Development Organization is related to an organisation structure, roles, incentives, and norms, which is an important support for the efficiency of the FEI. PP0 is responsible for performing Preliminary Opportunity Identification, Market, and Technology Analysis. In this case, the two most expressive concepts regarding the number of contributions are representing the two parts of the Model, respectively the Foundation Elements and the Front End itself.

Concerning the areas that have received less attention, we can mention Product and Portfolio Strategy (PPS), P1 (Phase One) and P0 (Phase zero) which depict a low number of publications. It is in Phase One that feasibility issues and project planning are dealt with. Moreover, it is in Phase Zero that the product concept and definition are shaped. On the other hand, Product and Portfolio Strategy address the need of a clear product strategy and a well-planned portfolio of new products.

Figure 6 illustrates the inner parts of the "Three Phase Front End Model" (Khurana and Rosenthal, 1997, 1998) depicting attention received over the last years.

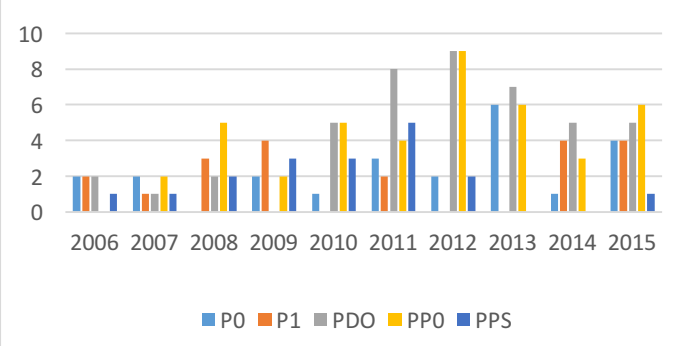

Fig. 6. FEI publications through the lens of the Three Phase Front End Model

5 Discussion & Conclusion

The evolution in the number of publications over time reveals the emergence of the FEI in recent years. Until 2005 this topic received limited attention. In 2006 the research focus started to widen with the first publications on the topic of "Opportunity Identification" (OI). Special attention must be be given to years 2011, 2012 and 2013 that show an increase in the number of papers and the broadening of research perspectives, thus bringing more diversity of contributions to the FEI research (see Table 3 and Figure 4). This could suggest that an in-depth understanding of the FEI phenomena may have fostered the need to open up research into new directions.

In the context of the NCD Model classification framework, the substantial lack of contributions to topics related to Leadership, Enabling Sciences and Technologies, Culture, Idea Selection and Opportunity Analysis is clear. The relative weight of these components is illustrated in Figure 7 as percentages, where Leadership and Idea Selection get only 1%, the lowest value.

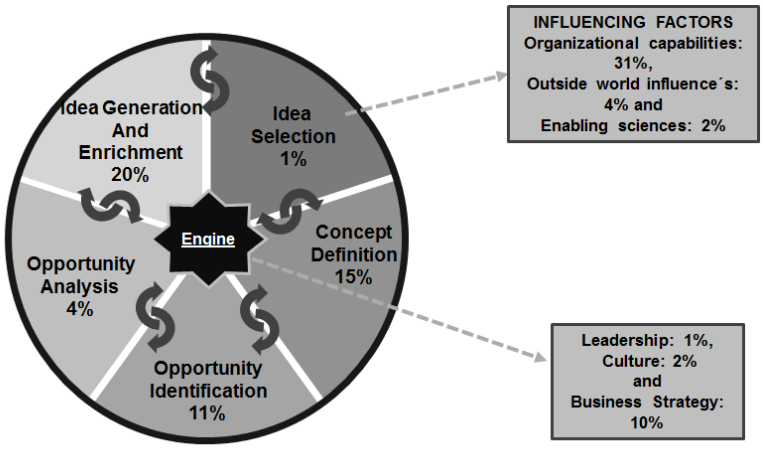

Fig. 7. Research findings through the lens of the NCD Model

As regards to the "Three Phase Front End Model," results show that the area with less emphasis is "Phase One" covering topics related to the analysis and decisions

about the feasibility of the developed concept; and the issues related to project planning. Figure 8 pictures the relative weight of the different "Three Phase Front End Model" components.

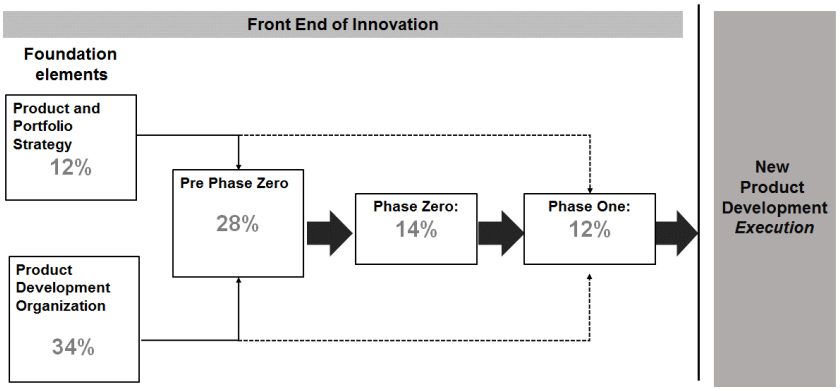

Fig. 8. Research findings through the lens of the Three Phase Front End Model

In both models, the topics addressing organisational issues were the ones that received more attention. Organisational competencies are indeed important as they may be considered as the means of providing the basis for FEI activities.

The findings show that the FEI has received more attention in recent years. Concerning the "NCD model", the parts more frequently addressed in the research were "Organisational Capabilities", "Idea Generation and Enrichment", and "Opportunity Identification". These results are aligned with the findings resulting from the projection into the "Three Phase Front End Model" that reveal more attention given to "Product Development Organisation" (PDO) and "Pre-Phase Zero" (PP0). This latter phase covers the "Preliminary Opportunity Identification," and the "Market and Technology Analysis".

The topics that were addressed less frequently in the literature in the context of the "NCD Model" were Leadership, Idea Selection, and Enabling Sciences. These topics are not explicitly handled in the "Three Phase Front End Model" and would likely fall into "Product Development Organisation" (PDO). The higher granularity of the "NCD Model" leads to a less concentration of publications per topic, in contrast to Table 6 where the lower granularity of the "Three Phase Front End Model" leads to a less unbalanced distribution of publications in each phase.

Evidence shows that the FEI has received greater attention in recent years both regarding depth and number of publications. In this context, and beyond the analysis conducted in this literature research, there are still pending gaps, namely:

- Regarding the applicability of modern approaches in FEI, Gonzáles (2014) uncovered insufficient findings for the use of agile project management;
- There is little research focusing on the Management of this phase of the innovation process (Robins and O'Gorman, 2015);
- Eliens and May (2015) highlight the high number of publications related to tools and methodologies. Although these works bring some insights to the field, most of the contributions address the effect that a specific tool has on a particular FEI process. As a result, many publications do not generate a substantial amount of knowledge for the FEI research field as a

whole. There is a lack of contributions regarding the so-called process activity models (mapping of the entire FEI process).
- The FEI requires a holistic approach and an innovative mindset. Possible trends worthy of investment are related to the use of ICT technologies. For instance "software to explore and track technological trends, nethnographic procedures to observe user behaviour and collect user ideas online, technical advancements to increase the validity of virtual prototyping" (Gassmann and Schweitzer, 2013, p. 302). An example of such research effort may be found in Barradas and Rodrigues (2016).

The "front-end performance favourably and independently impacts overall product success, time to market, market penetration, and financial performance" (Markham, 2013, p. 77). This stresses the relevance of building a comprehensive body knowledge in the area of the Front-End Innovation as a multi-disciplinary research domain. It would be beneficial if future research could promote a holistic understanding of the Management of the entire Front-End Innovation processes, across the different "NCD Model" perspectives, thus resulting in an increased innovation process performance. This might be particularly helpful for Entrepreneurs and Companies alike, who seek to improve their innovation capabilities.

6 Limitations of this research

The limitations of this research result from:

- The restrictions on the survey conducted in the database related to the use of the term "Front End" of Innovation which may have left out some other terms that represent this phase of the innovation process.
- The survey was performed in one database only; however, comparing Scopus with Web of Science, the former is the one with the largest breadth of coverage and number of journals (Öchsner, 2013).
- The analysis did not take into account environmental issues, organisational structure and organisational decision making (Child, 1972).
- The classification was made using the "NCD model" and "Three Phase Front End Model" frameworks and represents the best fit resulting from the author's perspective. Despite this, the author tried to reduce possible causes for any interpretation bias. To this end, this classification was reviewed in three different moments in time separated by a period of 3 to 4 months. All the classification revisions were made against the same framework of analysis. In future analysis, it could be interesting to use an approach based on a consensus classification process.

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Efforts to build a culture of innovation in the Brazilian energy sector

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Abstract. Innovation and innovation management are essential topics for any organizational system nowadays. Public services, commercial and industrial corporations are pressured to study, plan and promote innovations as strategic pillars for their activities and reputation in their competitive scenario. This paper analyzes the efforts on building and improving cultural factors that can foster innovation and innovation management in a critical, competitive and technology-driven sector of electrical power production in Brazil, examining records from ANEEL, its regulatory agency. From these records, values and facts concerning Brazilian program for investment in innovation were evaluated, together with related projects data, showing results that indicated: (a) Investments were conducted in mandatory fashion, not following strategic policies; (b) Expressive amount of investments were also done in the basic and applied research, not offering fair perspectives on more qualified or value-aggregated innovations and; (c) This investment program, executed by the regulatory agency, is opportune to sponsor innovation in this important economic sector. Methodological aspects, such as indexes choice, comparisons and analysis applied in this paper can also build a basis for other studies around the same context, allowing further comparisons to other sectors – such as those in this value-aggregated chain or even with other countries, with perspectives of richer results that can provide another level of innovation investments programs comprehension.

Keywords: Culture of Innovation, Energy Sector, Brazil, ANEEL.

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1 Introduction

The importance of the knowledge and technology is undeniable for the balanced and sustainable development of the nations. This effect can be evidenced on product innovations, the more knowledge and technology are inserted to the new products and services, the higher your market value, consequently more benefits to society, through boosting the economy and improving the quality of life.

The investment in Research and Development (R&D) became a crucial factor for most sectors of the economy to prosper and exceed the challenges that concern them. In the eletrical power sector, this situation is strongly identified, considering its stong influence to the economy, environmental, politics and others key sectors for the development of nations.

The culture of innovation in Brazil was started recently, this theme gained more attention since the 90's, through the creation of support mechanisms to the productive sector in the context of policies in science, technology and innovation.

This study intends to contribute to an analysis and evaluation of the innovation policies in Brazilian eletric power sector. Therefore, the purpose is to analyze and evaluate regulatory framework in Brazil in relation with innovation efforts to create a culture of innovation at national level. The methodological procedures were based on descriptive statistics through secondary data collected from ANEEL database (submitted proposals by companies to "R&D Program ANEEL", available on the agency's website).

Although can be listed numerous benefits of the R&D Program of ANEEL, the results released until now draw attention to some aspects: Of the 2257 projects between 2008 and march 2015, only two are market production insertion. This reflects the need for projects with more applicability and greater technical and economic impact for the Brazilian electricity sector. The need for more practical application of the projects, originated new products to market, was encouraged by ANEEL when proposed changes to the program. On that occasion were created mechanisms which encouraged the development of projects with proposals for potential new products insertion into the market.

Figures relating to the projects of R&D ANEEL between 2008 and early 2015 show that program structure had no effect so far after changes. The creation of mechanisms to encourage the development of Market production insertion, by itself, was not sufficient. It is necessary to step back and see how these projects are being perceived by the companies. The mistaken view of investing in R & D to fulfill obligations imposed by the regulatory mechanism of ANEEL, could compromise the performance of this sector.

The creation and consolidation of the program proposed by ANEEL is an important step forward for the technological development of the Brazilian electricity sector, however, the role of innovation culture needs to be strengthened further in this context. Finally, some important concepts should be incorporated in this environment to ensure the successful operations of such mechanisms, for example: collaborative networks, institutional partnerships, innovation management, innovation indicators, commitment to results, innovation strategy, among others.

2 Concepts and Premisses of Innovation

Conceptualize innovation and its associated management principles are constant reviews against the common-sense understanding. These problems are caused mainly by the remarkable market events produced by some product innovations, as those emerged from information technology, automotive, aerospace and mobile communication sectors. Although supported by the background theoretical reviews, they can be considered as some ways on how innovations can modify people´s lives, including when considering us in the organizational context as members of several organizations, for example, employees of market companies.

2.1 Innovation

Although referring like new ways of production or for entrepreneurial activities, the citations by Joseph Schumpeter are considered as the first landmark for this conceptual work. In its fundamental work – Schumpeter (1934) – he announces six types of "new combinations" of entrepreneurship, in order to promote social changes. These definitions are stated in Table 1 below:

Table 1. Innovation concepts

Innovation as…	From Schumpeter (1934)
Product	"a new good" (or a new quality or functionality).
Process	"a new method of production…" (with a reference to fundamentals on a scientific definition or new ways to handle products for commercial offering).
New market	"a country…" where a manufacturer have not entered yet.
New source of supply	"of raw materials…" or semi-manufactured goods.
New organization	As the creation of a "monopolist" positioning by a competitive strategy on a new market.

Source: Authors (October, 2015).

These concepts are discussed, debated, validated and supported by many authors and organizational sources since their original edition. For example, the Oslo Manual (2005) refers to TPP – technologically-supported products and processes – or new actions or approachs to propose, define, plan and implement new product lines and related processes in organizational environments which are based on technology support and scientific applications.

From Drucker (1985), it is possible to understand a wider conception for an innovative process, reinforcing "as a process", "a new market" and "new organization" definitions, when this remarkable author studied and proposed several analyses on businesses process. In his view, these processes were oriented to support business negotiations with final customers (new market, process) and advantageous strategic positioning

(new organization), corroborating Schumpeter definitions.

Interestingly, from Utterbach (1994), it can be seen a thorough discussion around the innovation concept, in which this important author validates some of Schumpeter findings, promoting a proposition of one new view. In this work, Utterbach compares, immediately, innovation products and process lifecycles, observing how they appear in national innovation systems and can be implemented in industrial and services organizations. His work focuses on designing a model for innovation lifecycle, approaching several real cases, adjusting these to a generic context that, at the end, will serve to understand his propositions to comprehend how one innovation is firstly introduced in a market, then develops its acceptance, technological adjustments and, finally, ends its commercial, technologic and social impact, receiving progressively less changes, becoming a "commoditized" version of a product or process. He also depicts, as a result of these observations around innovation as products and processes, the understanding about new ways of organization, as a response to changes in processes and new ways of products supply, as an integration of processes to provide new products to final customers.

This market-oriented view results in an opportune conceptualization on how competitiveness provokes innovation, which eventually leads to understand how a new type of innovation – that produced by market competition – is also conceptualized.

In a practical consolidation of this first view, the works by Schumpeter and Utterbach result in six different conceptions for innovation (as we combine four of them, considering them as equal, observing the two remaining as additions), which are: (Innovation as…) (1) Product; (2) Process; (3) New organization; (4) New market; (5) New source of supply and (6) Result of competitive forces.

It is also interesting to observe that Strategy is a collateral concept which can be intensively observed in each of these definitions, and also when they are taken combined. These concepts also cannot be faced as exclusive, or, as supported by many authors as those already cited in this section, strictly demanding that one innovation is "only" from one type. It is reasonable to think that the introduction of a new product may demand a new idea to offer, or also a new way to position, promote and sell it to a new market, combining two or three conceptualizations (Drucker, 1985; Davila, Epstein & Shelton, 2006; Bés & Kotler, 2011).

There are numberless definitions for innovation, usually as contributions from academic and scientific areas such as Strategy, Marketing, Human resources management, Information technology, Computing Science, Engineering (several different fields), among many others. For the purpose of this review, those first six definitions, added by the qualifications discussed below, are sufficient to announce the following study about a system to manage innovation in organizations.

2.2 Qualifying an innovation

Additionally, many views for innovation initiatives, processes and planning, result in complementary approaches, that are affirmed as "qualifying" for the innovation concept. First, it is opportune to approach, as announced by Engen & Holen (2014), citing Tushman & Romanelli (1985), the discussion around radical and incremental innovations. Radical innovations, as it happens with the common-sense perception of

considering product as the only type of innovation, is regarded as "the innovation" whatsoever. It is a major change, a disruptive action to propose something completely new, in which will mandatorily replace the older offer – product or service – with a complete new applicative scenario. But, carefully analyzing markets, strategic positioning and marketing stories, it is easy to perceive, as studied by these authors, several cases of small changes, applied to already existing components, parts or even complete commercial solutions, that were really successful. These small but identifiable changes, which resulted eventually in new ways to use products and services, are regarded as incremental innovations.

Davila, Epstein & Shelton (2006) analyzed, in a very detailed and analytical way, how technological and business model drivers should be observed to define if an innovation can be defined as radical, semi-radical or incremental. In their model, three drivers for each dimension – technology and business model – must be evaluated to check if there was, on one hand small, on the other hand, expressive sustainable changes from the former offer, resulting in those three qualifications.

Another approach, focusing more on the process innovation itself, was previously announced by Henry Chesbrough, He defined a context of intense, interactive, cyclic and perennial cooperation of economic agents to innovate, called "Open Innovation" (Chesbrough, 2003). In this proposition, innovation planning, design and implementation is an intensive cooperative context, where signals, information, communication and knowledge flow around the value-aggregated organizational chain, integrating customers and other economic agents, as participative elements to produce the original concept for any proposed innovation. This context diverges from the "closed innovation" former view, where an organization tries to develop its new types of innovation completely by itself, generally working to offer the final conception to the market, eventually dictating how customers will receive it. In general, approaches to Chesbrough works, this "closed" fashion is related to older, strict and classical markets-oriented corporations, progressively becoming extinct by new competitive models and competitive scenarios.

2.3 Innovation Management

Taking into account those different conceptualizations for innovation, its related management is also complex and broad, becoming challenging to focus for a conceptual base detail. First, it is recommendable to understand what can be regarded as innovation management, how it can occur in real organizational arrays and, after these steps, understand how it can be defined.

Observing in the former subsection, it is possible to define innovation from six different points of view. As a product (the most usual and perceived), as a process, as the relationships with new markets and customers, as new ways to organize the final customer service (new organizational models), as how to apply new basic and modified supplies, basic materials and, finally, as results of competitive reactions. It is provocative to think, analyzing from the literature discussed before and from other sources, presented in the following, some possible contributions to manage innovation.

The principles to build such way of thinking is to merely observe how each type of those six definitions of innovation demands specific management principles,

fundamentals and actions and perceive, in an initial view, some management areas and tasks which are demanded by all those six types, in general. The following text discusses by this way, presenting its references and, in the final, a consolidation is produced.

Innovation as product requires principles of Project Management – PMBoK (2012) – specific Engineering, Design, Production Engineering – Trott (2011) -, among several other themes that define and build logic and organizational fundamentals, proposed to structure the production of "something" tangible, eventually never tested before and also functionally acceptable by customers (Christensen, 2015). It is interesting to notice that, as said before, this type of innovation is immediately perceived by customers, in general, then any other type mention previously, also showing the largest base of references discussed by researchers and practitioners for the first decades of 20th Century, just because the other forms to innovate weren´t so much noticed as strategic resources by organizations.

Innovation as process is more understood from other points of view, like those related with business process management, being better exemplified with the approach of processes that namely deal with the "flow" of strategic, production materials or even critical resources, as information or money (BPM CBoK, 2013; Hill, 2015). Modifying a process is not a completely transparent innovation for final users, frequently aiming to improve, optimize or at least change some internal organizational aspects. Although this lack of image for external agents, processes innovation in areas like Finance, Supply chain and Production management eventually produce quantitative results of impact in overall organizational performance.

New markets – in the sense of creating it or even exploiting an old one in a new approach – are usually discussed by Marketing disciplines (Kotler and Keller, 2015). Several evidences from new markets observed occurred in the last years. Emerging markets, such as those from instantaneous, impulsive and sometimes unsustainable national Economies (like from the countries of the BRICS block), demanded new forms of supply, businesses models, competitive regulations, among other actions and agreements. Marketing, Production, Human Resources, Commercial and some other professional areas were dynamically adapted to deal with these new competitive fronts. This resulted in a practical productive scenario where scientific and academic knowledge have to be produced and applied in a sudden, eventual way (Johnson, Christensen & Kagermann, 2008).

As a result from the two former types of innovation – process and market – or even as new, stand-alone innovative approach, one organization can also define a new structure to answer changing competitive external signals, as fast customer change of preferences, invasion by an external competitor or even a risk of technological replacement (Weldeken, et. al., 2014). New design for business models, an event that is still being studied and not correctly comprehended by entrepreneurs and other economic agents, is remarkably being proposed by new competitive organizations, as social media providers, sharing resource partnership promoters (as AirBnB or Uber), industrial dynamic outsourcers (as micro-factories that are now producing from beer to car parts) or by integrative platforms of services, as entertainment tickets sellers or food delivery firms (Dijk, 2015).

New ideas of treating old materials, or even integrating or exploiting these old basic

supplies in another way and also exploiting new materials, are also interesting fronts of innovation, as approached by Dangelico & Pujari (2010) and Gerstlberger, Knudsen & Stampe (2014). It is opportune both to affirm about the technological front, where technical and engineering approach are increasingly successful, and observe how the sustainability issue also provokes researchers and practitioners to understand new materials and new ways for handling of the old ones impact the environment, demanding by this way new degrees of comprehension on how innovations from this kind are valuable for humanity.

Finally, competitive forces, as those presented by Strategy authors who studied Innovation –Porter (2008), Mintzberg, Ahlstrand & Lampel (2009) and Barney (2011) – are recognized as a drive for organizational innovation. Several demands from markets, as new ways to optimize human resources management, finance, supply chain, productive arrays and other aggregated-chain components are examples of these competitive requests for innovation. Organizations competing in these new markets face the demand to change promptly their conditions to understand and propose a productive rivalry, integrating their efforts to occupy market spaces and improve the final customer perceived value.

2.4 The Integrative Context of Innovation Management

As stated in the last subsection, innovation management is a complex and unlimited context, where several management techniques and methods play a decisive role. Concluding this objective view of innovation management, is opportune to mention its integrative context referring both to the fact that it integrates these relevant disciplines of technological and managerial contributions and is, mainly, open to additional thoughts that aim to allow one organization to produce and interact with innovations.

Among the topics that can be easily identified in the literature, it is important to define Strategy as the base for innovation management composition. Strategy can be regarded as one coordinated view for one organization´s future (Porter, 2008; Mintzberg, Ahlstrand & Lampel, 2009). This coordinated view must consider innovation, in the proposed broader view conformed conceptualized before, as a strategic formulation component for one organization.

Innovation can be proposed as, for example, a new process to answer customer demands for more flexible services or even to correctly point out a new focus for launching a specific product, as a result for the availability of new technology (Ma, Jill & Ziang, 2015). Thinking this way, it is possible to affirm that even when it is considered that innovations must disrupt a company´s strategy, it is perceivable that this rupture occurs with meaning to former objectives, supported by new approaches to goal definitions processes and specifications for tactical and operational plans, i. e., it considers the rupture from a conventional, traditional strategic view (Christensen & Raynor, 2003).

Another considerable observation is that one can propose innovation as a part of the organizational strategy, but the strategic proposition, itself, can become an innovation (Ettlie & Reza, 1992). For a development of this affirmation, it is possible to understand the characteristic of strategic planning – it is one organizational process, defined by several authors as “the” organizational process” (Hammer & Stanton, 1999), as the

main integration flow for corporative decisions and implementations. The process itself, as it is possible to observe in new business models, can differentiate from a traditional, up-down, scaling process (Porter, 1998) to new interactive methods, although with the same overall guidance main objectives (Sniukas, 2015).

Another way to think is that strategy regards innovation, as conceptualized, for organizational future positioning. As strategy is unfolded in strategic-tactical plans, defining potential relationships of management areas of one organization to achieve predicted goals, it is important to understand these innovation management components. A brief observation about those areas / subjects that support the organizational strategy focus themes such as Human Resources, Marketing, Commercial, Logistics, Information systems design, Communication, Financial, Operations, Project Management, Production among others, where its specific plans must consider innovation culture and management to produce suitable scenarios that allow to propose innovations as a result of strategic thinking and planning.

Specific approaches to these areas are beyond this first-level theoretical review, although it can be oriented by some of the titles referenced until this part of the study.

3 The Energy Sector in Brazil

An important movement in the Brazilian energy sector occurred through Law 9.991/2000, established by Brazilian Electricity Regulatory Agency (ANEEL). This law provides investments in R&D by concessionary enterprises, permissionaires and authorized companies of the electric power sector. Thus, this law requires obligatory investment, of at least 1%, net revenue from companies in the sector. The initiative is known as "R&D Program of ANEEL".

It is important to note that from 2008 there were some changes in the structure of the R&D Program ANEEL, including the new classification modalit:

- Basic Research (BR)
- Applied Research (AR)
- Experimental Development (ED)
- Head Production Series (HD)
- Piooner Production Lot (HS)
- Market Production Insertion (MI)

These classifications of projects identify the stage of maturity of the businesses proposals, in addition to greater dissemination of results.

In this sense, considering that it's been more than 10 years of this investment effort in innovative projects in this sector, some studies have already realized to assess the performance of this regulatory framework as a study conducted by Institute for Applied Economic Research (Ipea) in collaboration with ANEEL. The results obtained showed strengths and points which needed to be strengthened that the programme could be more efficient.

3.1 The role and intervention of Brazilian Electricity Regulatory Agency (ANEEL)

According to Powder and Abrucio (2004), one of the results of the state reform process

in Brazil was the creation of regulatory agencies. During the first generation of reforms have created regulatory agencies related to the privatization and break of the state monopoly in the sectors of infrastructure, cases of the National Electric Energy Agency (Aneel), the National Telecommunications Agency (Anatel) and the National Petroleum Agency (ANP).

This first generation of regulatory agencies, created since 1996 in the context of privatization, breaking the state monopoly and inspired by international experience, was set up as public entities endowed with independence from the executive branch. In its creation the work of the Congress was important, as well as the recommendations of the Council of State Reform, an advisory body attached to the President, though less participation of the Ministry of Federal Administration and State Reform (Mare) (Pacheco, 2004).

The creation of ANEEL project was sent by the Federal Executive to the National Congress in late 1995, later to the first privatization in the sector, causing some problems of legitimacy, especially regarding the arbitration of disputes (Salgado, 2003).

ANEEL was created by the Law 9427, on December 26, 1996 and regulated by Decree No. 2,335, on October 6, 1997, which approved its regimental structure. The Aneel management contract had its first version adopted in 1998 and the Target Plan approved in 1999.2 The agency, set up as an independent regulatory and linked to the Mines and Energy Ministry (MME), is to regulate and inspecting the production, transmission and sale of electricity in accordance with the policies and guidelines of the federal government. Aneel has managerial and financial autonomy and competence to regulate technical issues as well as decision-making autonomy, guaranteed by fixed terms of its board, whose conformation is designed to ensure technical quality and neutrality in their decisions.

The Law No. 9991 on July 24, 2000, changed by Law No.10,438, on April 26, 2002, No. 10,848, on March 15, 2004, No.11 465, on March 28, 2007, 12.111 on December 09, 2009 and No.12.212 on January 20, 2010, concessionaires of public distribution services, transmission and generation of electricity, the licensees of public services of electricity distribution and authorized for the independent production of electricity, excluding those that generate energy exclusively from wind installations, solar, biomass, qualified cogeneration and small power plants hydropower, should apply annually a minimum percentage of their net operating income - ROL in Research and Technological Development of the Electricity Sector - R&D, according to regulations established by ANEEL.

According to this law (Article 1), concessionaires and licensees of electricity distribution are required to apply annually a minimum of 0.75% (Seventy-five hundredths percent) of their ROL in research and development of the electricity sector and 0.25% (twenty five percent) on energy efficiency - EE in the final use, and should be subject to the transition period these percentage. As for the generation companies, authorized the independent production of electricity and transmission concessionaires were required to apply annually at least 1% (one percent) of ROL in research and development of the electricity sector. By Exemption, were excluded from the obligation companies that generate power exclusively from wind installations, solar, biomass, small hydro and qualified cogeneration, observing, for the latter, the provisions of

Resolution No. 652 of 9 December 2003.

That change occurred to modify the previous rules that force generation concessionaires to invest in research and development of electric power industry annually a minimum of 0.25% (twenty-five hundredths percent) of its ROL. To the distribution concessionaires that percentage was 0.1% (one tenth percent).

The projects should be guided by innovation, for the purpose of the market and technological challenges in the electrical sector. Thus, the R&D project in this sector needs to be original and innovator.

4 Methodological Procedures and Analysis of Data

This study was conducted through the submitted proposals by companies to "R&D Program ANEEL". As such, data were collected from ANEEL database during the period 2008 to 2014.

The data considered in this study was “annual expenditures on R&D Projects” reported by energy companies for the aproval by the ANEEL in the period from 2008 to 2014, i.e. after the establishment of the priority research themes, namely: Alternative Sources of Electric Power; Thermoelectric Generation; Basin and Reservoir Management; Environment; Security; Energy Efficiency; Electrical Power Systems Planning; Operation of Power Systems; Supervision; Control and Protection Systems for Electric Energy; Quality and Reliability of Electric Energy Services; Metering, billing and control of commercial losses, and others.

The table 2 shows the number of submitted and currently projects as well as the financial amounts to be expended.

Table 2. Investments by year and projects submitted

Year	Research and Development R$	Submission	Ongoing projects
2008	44.265.986,36	33	30
2009	483.321.604,26	301	102
2010	839.291.149,32	568	293
2011	1.110.007.426,81	483	301
2012	1.772.905.013,27	505	256
2013	586.246.812,17	168	98
2014	584.301.518,42	198	155
Total	**5.420.339.510,61**	**2.256**	**1.235**

Source: ANEEL (march, 2015).

The table above shows an increase in R&D by companies from 2008 to 2012. There is a sharp drop in investment due to the loss of revenue resulting from the companies' renewal of concession agréments, during the period 2013-2014, made by the federal government.

Concerning the number of submissions and the number of ongoing projects, the power company may at any time inform the ANEEL lack of interest in carrying out projects that have already been subjected to evaluation. This lack of interest may be of any type ranging from financial problems to the technology to be developed in the project be obsolete or have been exceeded. The project number is running 54% of the submitted projects, but when analyzing the total project investment financial expenditure decreased only 20%.

The Figure 1 contains information about the percentage of R & D projects from the project scope.

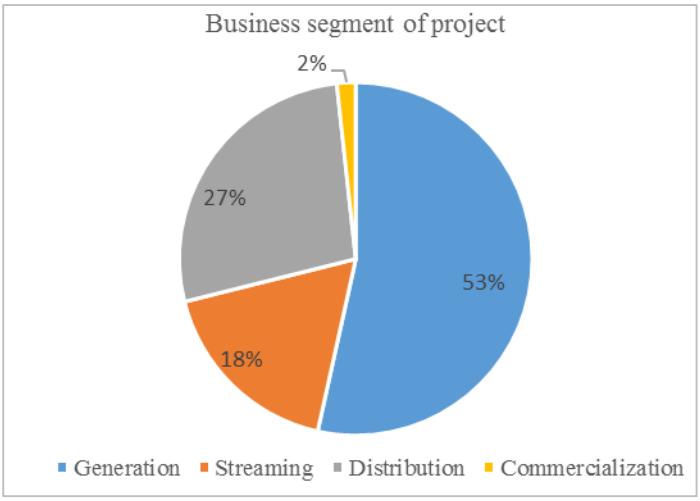

Fig. 1. Percentage by Bussiness Scope of Project (ANEEL, march 2015).

The graph shows that 53% of the Submitted projects are related to generation, 27% in distribution, 18% transmission and only two percent in energy trading area.

The Figure 2 present expenditures (R$) for projects research themes evaluated by ANEEL.

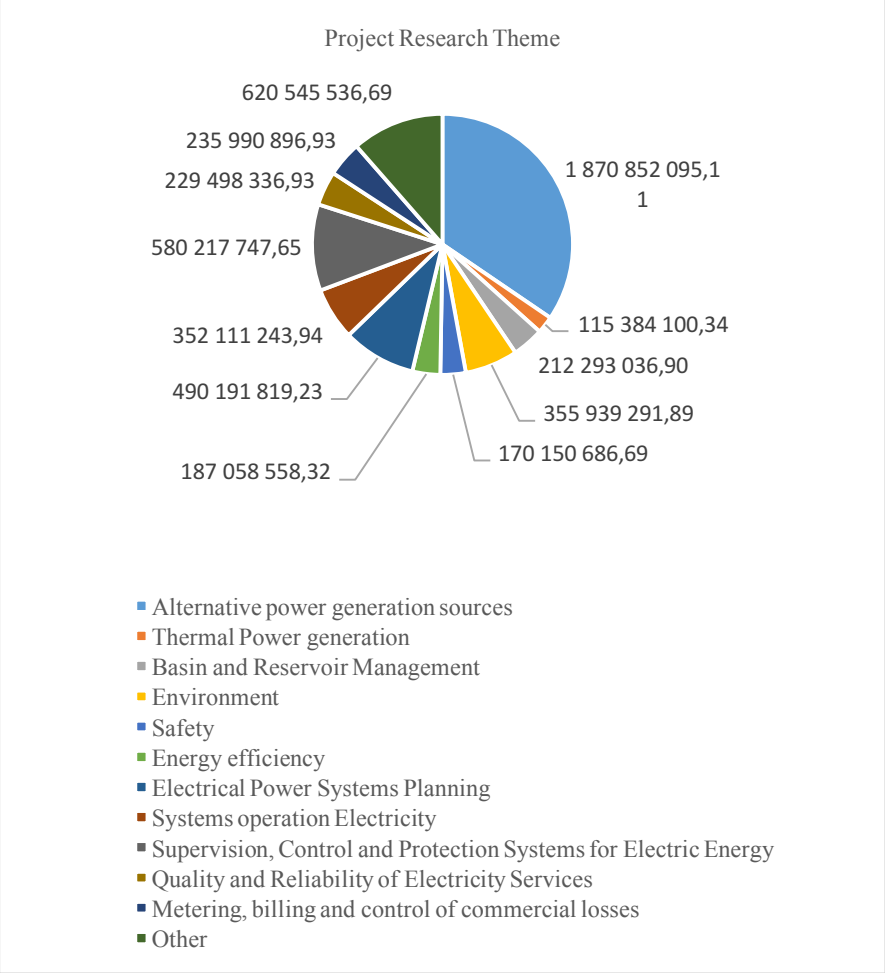

Fig. 2. Distribution of project research theme (ANEEL, march 2015).

It´s observed in the graph that the issue has the highest demand is the Sources of electricity generation alternatives with 35% of expenditure on research, followed by Supervision, Control and Protection of Electrical Power Systems with 11%, Systems Planning electricity with 9% and Environment 7%. The other theme accumulates 11%.

In phase of the Innovation Chain seen in the Figure 3, investments in research focus on applied research and experimental development.

In the analysis of expenditures by modality in the innovation chain is observed that 62% of this was allocated in Applied Research and Experimental Development 29%. These two items account for over 90% of investment in R & D fitting Basic Research 5%, Head Production Series 3%. The phases Market Production Insertion and Pioneer Production Lot account for less than 1% of the investment.

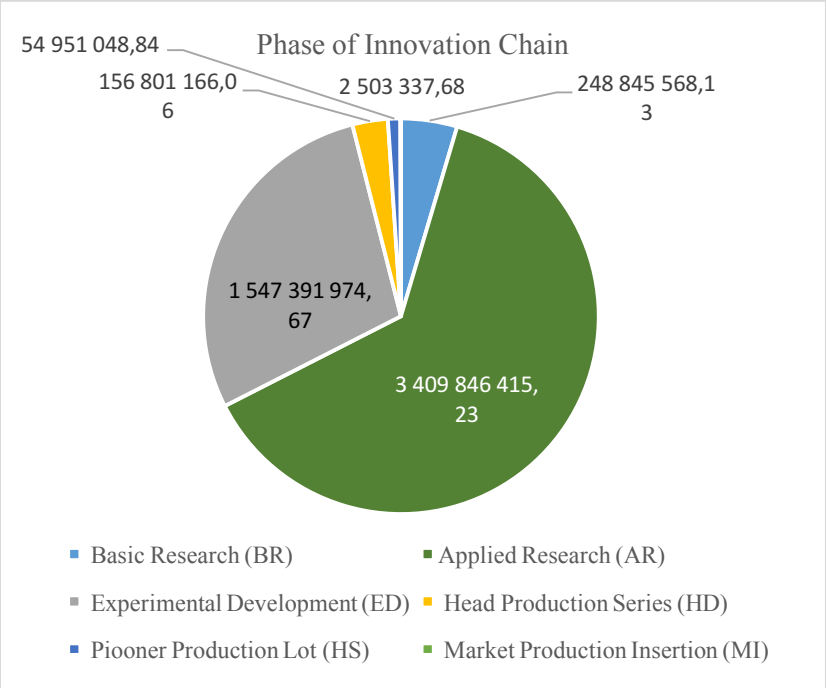

Fig. 3. Phase of Innovation Chain (ANEEL, march 2015).

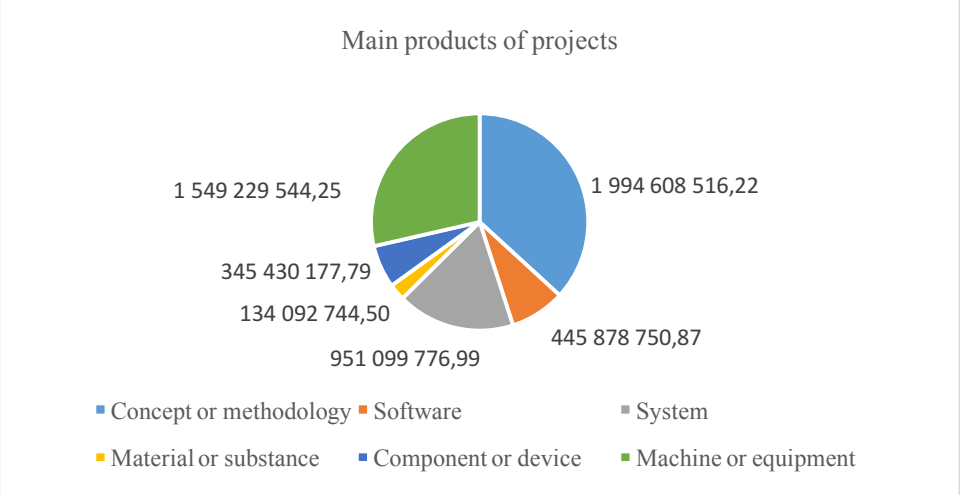

Fig. 4. Main products of projects (ANEEL, march 2015).

The expenditure related to the project's main product is closely linked results to academia, so 36% concerns to concept or methodology, followed by 28% Machinery and Equipment and 17% System. The remaining items as software component or device and material or substance amount to 19%.

The Intellectual property is divided between the power companies and the performers of the project, as conditions envisaged by Brazilian Innovation Law.

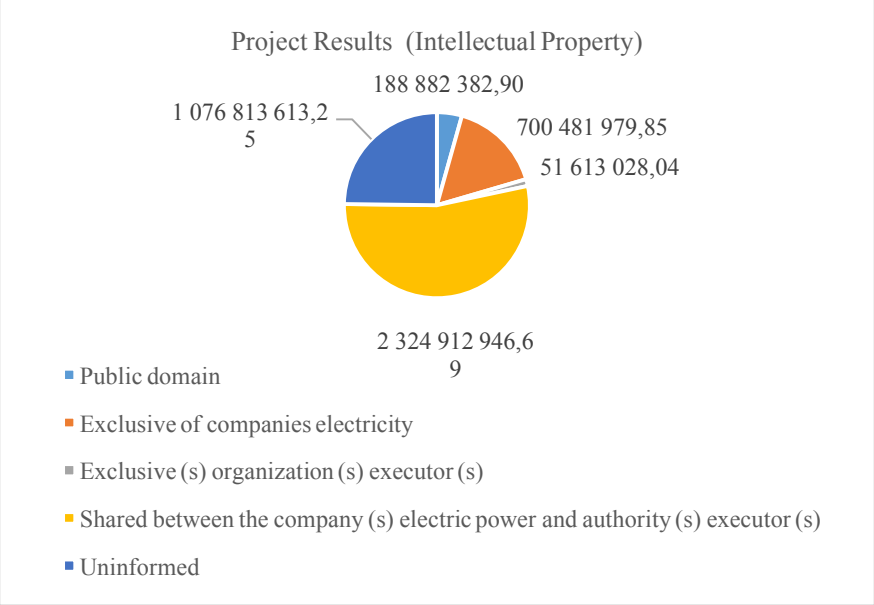

Fig. 5. Intellectual Property (ANEEL, march 2015)

In the Figure 5 it can be observed that the allocation of intellectual property of the results of projects being split between electric power companies and implementing agencies (54%), only 16% of the property is unique to electric company while in the public domain are only 4%.

Also that 25% of the ownership of intellectual property was not informed. Regarding investments can be seen in the graph below. The project submissions and the ones going to final are quite different.

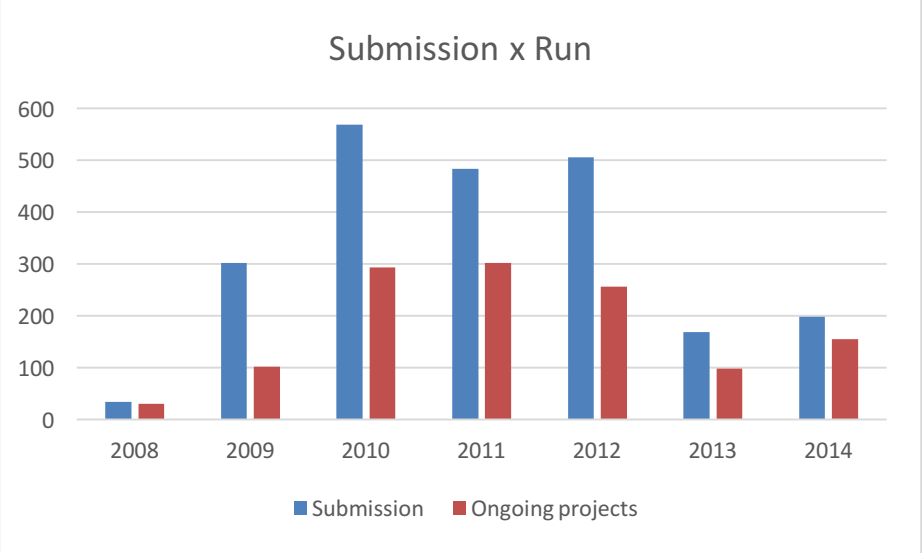

Fig. 6. Submission x ongoing projects (ANEEL, march 2015).

Analyzing the graphic (Figure 6) the rising line in R&D investments from 2008 to 2012, it can be observed that the population increased on average 0.9% per year, while per capita consumption showed an average growth of 3.8% per year in the period (EEAA, 2014).

This growth was due to the inclusion of low-income consumers under the Light for All Program (LpT). The program, over its 10 years of existence, accumulated more than 3 million power connections, representing 5% of all residential consumers in the country, and totaling about 15 million people benefited from access to electricity (EEAA, 2014).

The decline in the number of projects submitted and executed in 2013 and 2014 is due to the renewal of contracts for large dealers with the federal government, some claim loss of revenue that can be seen in the graph, since there is a requirement for investment in R & D, it can not be accumulated for more than two years.

5 Conclusion

In general, the program proposed by ANEEL brought to Brazilian eletric power sector a thousand of projects that were attended by hundreds of research institutions and qualified professionals in their developments. It is therefore important to mention that training and technological capabilities were direct benefits of R&D projects. In addition, new materials and processes have been incorporated to reduce costs, improve the quality of services, and improve the productive capacity.

The first conclusion is that 89% increase in the number of companies, now have the obligation of investment of ROL - Net operating revenue in R&D, from 49 companies in 2008 to 91 companies in 2014.

However, the billings and investments in R&D projects do not achieved the same growth rate as can be seen in the graph below, which shows the number of projects submitted and the number of projects effectively achieved.

The second conclusion is that Brazil is spending too much on basic and applied research, and the results are not progressing in the innovation chain, as the graph shows, the phases Market Production Insertion and Pioneer Production Lot, they account for less than 1% of the investment, i.e., only two and a half million have been invested in these final stages of innovation, a total of more than five billion real (R$) invested in these seven years.

Considering the relevance of the subject in an intensely strategic sector for the Brazilian economy, we encourage new future studies to examine the projects that followed the trajectory to market.

Finally, it´s worth mentioning that these efforts by ANEEL Program are essential for building a culture of innovation in the Brazilian electric sector. After the analysis performed in this study, we conclude that this challenge is associated with the global challenge in this sector, such as: strengthening the local industry competitiveness, supply chain development and development of new technologies.

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Emergence of Energy Services Ecosystems: Scenario Method as a Policy Enabler

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Abstract. The very nature of the energy sector, as a highly regulated and capital-intensive sector, as well as the challenges imposed by the global transition to renewable energy, have made the emergence of innovation ecosystems, which are necessary for the development and commercialization of new solutions, rather challenging. We examine the emergence of energy services ecosystems from a policy perspective, suggesting the scenario method as an enabler for focusing the attention of relevant actors and identifying triggering events that guide their activities toward a shared future. We illustrate our arguments using three case examples from Finnish public policy. Our study contributes to the nascent literature of ecosystem emergence and public innovation policy in the field of energy services.

Keywords: Ecosystem, innovation, emergence, energy services, scenario method, research policy.

1 Introduction

The literature on business and innovation ecosystems has been accumulating for over two decades, beginning with the seminal contribution by Moore (1993). The ecosystem concept has since attracted significant attention, especially within the body of practitioner and managerial literature, which has largely focused on how ecosystems can be managed around focal actors, technologies, or platforms (e.g. Iansiti and Levien, 2004; Iyer and Davenport, 2008; Rohrbeck et al., 2009; Williamson and De Meyer, 2012). Furthermore, research on innovation ecosystems has concentrated on how actors organize into systems around new developments, technologies, and ideas (e.g. Autio and Thomas, 2013; Ritala et al., 2013). One important question that is still rather untapped relates to how innovation and business ecosystems emerge: that is, how actors begin to organize themselves around interdependent ecosystems with shared goals, visions, and purposes. While self-organizing is a key attribute of business ecosystems (Peltoniemi, 2006), policy interventions are often helpful

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when ecosystems are being built around new technologies and innovations (Clarysse et al., 2014).

To better understand how ecosystem emergence can be facilitated, in this paper, we focus on how public policy initiatives enable the emergence of ecosystems around energy sector innovations. Existing literature has begun to study, for example, the role of public funding and knowledge in enabling ecosystem emergence (Clarysse et al., 2014). In the fields of renewable energy and energy services, facilitating the emergence of new business ecosystems is an especially relevant public policy context. While the literature on energy policy has identified the importance of public policy initiatives (e.g. Lewis and Wiser, 2007; Lund, 2007), there is still not sufficient evidence of the particular mechanisms that enable participants to focus their attention and cognition toward mutually shared goals and future development paths. In this paper, we suggest that scenario methods can function as public policy intervention mechanisms for enabling and facilitating the emergence of a new energy service ecosystem.

We frame our arguments within a hierarchy of systems, including both the broader national innovation system and the business and innovation ecosystems that emerge with (and without) the influence of the national innovation system. For example, the national innovation system consists of universities, research centers, large and small firms, and various legal and regulatory institutions. By the term energy services ecosystem, we refer to an innovation ecosystem consisting of both private and public actors interacting in various innovation- and business-related activities. In this sense, we build upon a recent conceptualization of innovation ecosystems as "clusters (physical or virtual) of innovation activities around specific themes (e.g., biotechnology, electronics, pharmaceutical and software)" (Ritala et al., 2013, p.248).

Our paper uses several case illustrations from Finland to understand ecosystem emergence in the energy services sector. The energy sector in Finland (and worldwide) is a highly regulated and capital-intensive sector, which makes the "natural" emergence of new energy services ecosystems rather challenging. Thus, we argue that, especially in this context, the Finnish innovation system can play an important role as an enabler for the emergence of new energy services ecosystems. We specifically concentrate on policy interventions and related scenario work as mechanisms that facilitate the emergence of new ecosystems, including, in our case, the energy services ecosystem. We argue that the scenario method and related processes focus the attention of various ecosystem actors, while also supporting the triggering events that guide future development. To support our argumentation, we examine three cases of different research programs financed by TEKES (the national agency for innovation development) and Academy of Finland innovation system strategic initiatives.

Recent literature has focused on the transformation from loosely coupled research and development collaborations to more determined business and innovation ecosystems (Möller and Rajala, 2007; Aarikka-Stenroos and Sandberg, 2012; Clarysse et al., 2014).

Another stream of literature has examined how ecosystems are built and how they emerge

in the first place (e.g. Moore, 1993; Ritala et al., 2013). Our study contributes to these streams of literature from a public policy intervention perspective, as we suggest that the scenario method and related processes can play an important role in the emergence of new innovation ecosystems. With this paper, we aspire to initiate discussion and inspire future studies on the impact of policy intervention on the emergence of innovation ecosystems: a phenomenon that is little studied. We argue that the potential of the innovation ecosystem may not be fully realized without such mechanisms as the scenario process. Using our case examples, we illustrate how potential knowledge and resources are mobilized for new ecosystem emergence, how the relevant stakeholders can create shared understandings of the future, and what kinds of triggering mechanisms can encourage passive actors to actively engage, take risks, and commit.

Our paper is organized as follows: We begin with a brief discussion of the emergence of ecosystems, followed by a brief description of the role of scenario methods for focusing and triggering this emergence. Next, we present three illustrative public policy cases in the field of energy services, focusing in particular on the attitudes, cognitions, decisions, and actions of relevant actors participating in the scenario method and related processes.

2 Understanding the emergence of ecosystems

The innovation ecosystem, as a concept, has been used to describe the increasing emphasis on the interdependency and co-evolution of individual actors (Autio and Thomas, 2013), such as suppliers, customers, governments, and universities. A seminal contribution to the literature of ecosystems in the business and innovation context was made by James Moore (1993), who adopted the biological metaphor of the "ecosystem" to describe how organizations and individuals interact and evolve in systems that operate very similarly to those that we can observe in nature. The key insights, which were later developed by other authors, were built on the systemic nature of ecosystems, including the principles of shared environment, co-evolution, interdependence, and ecosystem leadership (e.g. Moore, 1993; Iansiti and Levien, 2004). Recently, the scope of the term "ecosystem" has expanded significantly to include platform ecosystems (e.g. Thomas et al., 2014), technology ecosystems (e.g. Wareham et al., 2014), and service ecosystems (e.g. Akaka et al., 2013).

The birth and evolution of ecosystems has been one of key topics ever since the seminal contribution by Moore (1993), who established the concept of the ecosystem life cycle, which consists of steps of birth, expansion, leadership, self-renewal, and decline/death. However, the main focus of ecosystem literature has been on explaining or solving issues faced by the focal actor or the ecosystem leader (e.g. Iansiti and Levien, 2004). Specifically, prior literature has widely studied how focal actors operate in ecosystems and how they create and organize them by imposing rules for other actors. Empirical investigations of large, incumbent companies and their already established ecosystems have represented the main approach in much of the extant ecosystem research (e.g. Iyer and Davenport, 2008; Isckia, 2009; Rohrbeck et al., 2009).

Prior literature either implicitly or explicitly grants significant power to the focal actor in designing the innovation ecosystem, neglecting the roles and influence of other, non-focal (e.g. entrepreneurial) actors within the ecosystems they inhabit (e.g., Ozcan and Eisenhardt, 2009; Hallen and Eisenhardt, 2009). As stated earlier empirically, the innovation ecosystem literature has largely studied innovation ecosystems organized around a technological platform (e.g., Gawer and Cusumano, 2014; Wareham et al., 2014) or a single focal actor (e.g., Leten et al., 2013), assuming that this focal actor can direct the future of the ecosystem as a whole. However, this approach is rather myopic, since the key to the emergence of innovation ecosystems is the connection between micro and macro behaviors and the cooperative and competitive interactions among individual actors (Smith and Stacey, 1997; Peltoniemi, 2006). Namely, *emergence* refers to the phenomenon through which individual actors' motives and actions lead to unpredictable population-level behavior (Peltoniemi, 2006). In other words, emergence occurs as a result of dynamic interactions and coevolutions among individual actors that lead to unanticipated outcomes, such as the rise of larger entities (e.g. innovation ecosystems that exhibit properties possessed by none of the systems' actors) (Holland, 1997; Midgley, 2008). Simply put, the whole is larger than the sum of its parts. Further, when the link between action and long-term outcome is lost in the interactions between the actors and the system, it is impossible for an external actor or powerful member of the system to control or design the system's behavior. Instead, the behavior emerges (as described by Smith and Stacey, 1997, p.83).

In innovation ecosystems, unlike in biological ecosystems, selection forces are not unknown to those experiencing them; instead, they involve learning and deliberate efforts by purposive actors to influence their environment (Garnsey and Leong, 2008; Garnsey et al., 2008). Therefore, Garnsey and Leong (2008) argue that actors can deliberately transform their environments, including the very selection forces that act upon them. This indicates the scope for proactive decision making and motivated action (cf. Penrose, 1995, p. 3). In fact, we argue that investors and policy makers, as members of the wider innovation ecosystem, are in a position to influence the emergence and methods of operation of the forces of selection (see Garnsey and Leong, 2008; Clarysse et al., 2014). For example, through well-informed financial and networking support, these individuals are able to enable the emergence of the innovation ecosystems necessary to support the commercialization of emerging technologies (Garnsey and Leong, 2008). However, as Clarysse et al. (2014) show, policy makers' support for research programs seeking knowledge creation does not automatically trigger the emergence of innovation ecosystems, since the value creation processes of innovation ecosystems are significantly different, implying that policies to support innovation ecosystems must be specifically tailored.

The energy services ecosystem can be viewed as a complex system (see Cilliers, 2001) which is subject to constant inflows and outflows and which evolves over time. The system consists of actors, activities, and processes that are interdependent. The ecosystem evolves through changes in the actors themselves, as well as collective, system-level co-evolutions stemming from internal and external influences. During the process of emergence, the relevant actors appear and begin to conduct activities that are (at least partially)

interdependent from those of other actors. The actors also begin to coordinate their activities, with each taking a different role in the ecosystem (Moore, 1993; Iansiti and Levien, 2004). In order for innovation ecosystems (as social structures) to be sustained, there must be interactions among actors that are sufficiently recurrent and personal to create shared understandings, legitimations, and relations of acknowledged interdependence (Giddens, 1984).

We view the role of the *knowledge* and *shared cognition* of ecosystem actors as an important precondition for emergence. We argue that one key benefit of the emergence of innovation ecosystems is the production and combination of knowledge necessary for innovation, which is dispersed among different, previously unconnected actors. Thus, an innovation ecosystem can be viewed as an integrating mechanism that allows for both knowledge exploration and knowledge exploitation (Valkokari, 2015) and that enables its actors to jointly address complex problems (Leten et al., 2013). Furthermore, we claim that innovation system-level policy tools and mechanisms can make such knowledge visible and provide opportunities for the actors who are potentially forming an ecosystem to create a shared vision and agenda. In particular, we focus on the scenario method as an intentional process that can *focus the attention* of ecosystem actors, *enable the necessary social interaction*, and facilitate a *shared cognition* over triggering events that guide actors towards a shared and plausible future. In the following section, we discuss the role of the scenario method as an enabler of ecosystem emergence.

3 Scenario method as an enabler of ecosystem emergence

Scenarios are means to affect future development. The fundamental idea behind the scenario approach is *to provide a structured way to create a dynamic and ongoing social interaction among individuals and to expand people's thinking* (Wack, 1985a; Wack, 1985b; Schoemaker, 1995; Schwartz, 1996). Scenarios express the vision and aims of a certain group of stakeholders. They help organizations and individuals develop and broaden the strategic thinking on possible future realities and facilitate an understanding of the fundamental drivers of business, market, and technological trends and changes (Masini and Vasquez, 2003; Wack, 1985b). Scenarios describe the complexity of phenomena that cannot be formally modelled (Schoemaker, 1997). Scenario processes make it possible to assess the competitive landscape in a new light, revealing alternative future development paths (Godet, 2000; Schoemaker, 1997). In the process of strategy-making, the scenario method has been used to create a holistic understanding of complex environments to focus actors' operations towards a desired future (Schoemaker, 1993; Schoemaker, 1995). The use of scenarios reflects an organization's proactive orientation (Godet, 2000), enhancing its organizational flexibility to respond to environmental uncertainty and future actions. The scenario method can provide a structured approach for dynamic and ongoing interactions among organizations to create intentional strategic conversations and dialectic processes (Schwartz, 1996).

The scenario process is established when there is a need for influencing the development of an organization or wider business environment (Wack, 1985a; Wack, 1985b), such as, in our case, energy service ecosystems. Since, from a certain stakeholder point of view, scenarios are intentional, they seek to produce new knowledge and focus the performance of participating organizations. This scenario process can be set by a single organization or political decision makers to influence public and business organizations' decision making (Schwartz, 1996). Scenario networks vary from intra-organizational working groups to inter-organizational virtual networks, where individuals have access to a wider knowledge base, connections become more interactive, and more holistic interpretations are formed.

For the purposes of this study, we view the scenario method as an enabler of ecosystem emergence, which takes place through 1) focusing the attention of ecosystem actors towards a certain direction, 2) enabling social interactions, and 3) making visible the triggering events that have a strong effect on the perceived futures of ecosystem actors. Scenario methods enable such focusing processes and the subsequent discovery of triggering events, which, together, help to facilitate ecosystem emergence when relevant actors are involved and influenced by the scenario work.

First, scenarios are means to *focus* and communicate strategic intent with the organization and the wider stakeholder network. Second, as a structured process, it has been seen as an effective management tool facilitating social interaction in a networked context to explore the environment in order to understand complexity or recognize alternative paths to the most desired goal (de Jouvenel, 2000; Roubelat, 2000; Bergman et al., 2006). Therefore, the scenario process serves as a catalyst for channeling organizational resources towards new opportunities and goals. In other words, the scenario process works as a facilitated and structured context by enabling a group of individuals to serve as intermediaries (or interfaces) in interactions between the internal and external environments and by amalgamating them into a network to work on the same task under a shared vision (van der Heijden, 2002).

Third, scenario processes can *trigger* the involved actors' activities, thus leading them to address and develop resources towards shared goals. When there is a goal of affecting the development of industry or society, the shared vision is developed among the most influential stakeholders and disseminated to the wider stakeholder network to trigger the desired actions. Scenarios are descriptions of the most desired development paths toward these commonly accepted goals. They may provide new business opportunities or even trigger large-scale industry-level renwal.

Fig. 1 summarizes the role of scenario methods as policy tools in enabling ecosystem emergence by focusing actors' attention, discovering important triggering events that guide these actions, and identifying plausible scenarios that can be shared among ecosystem actors.

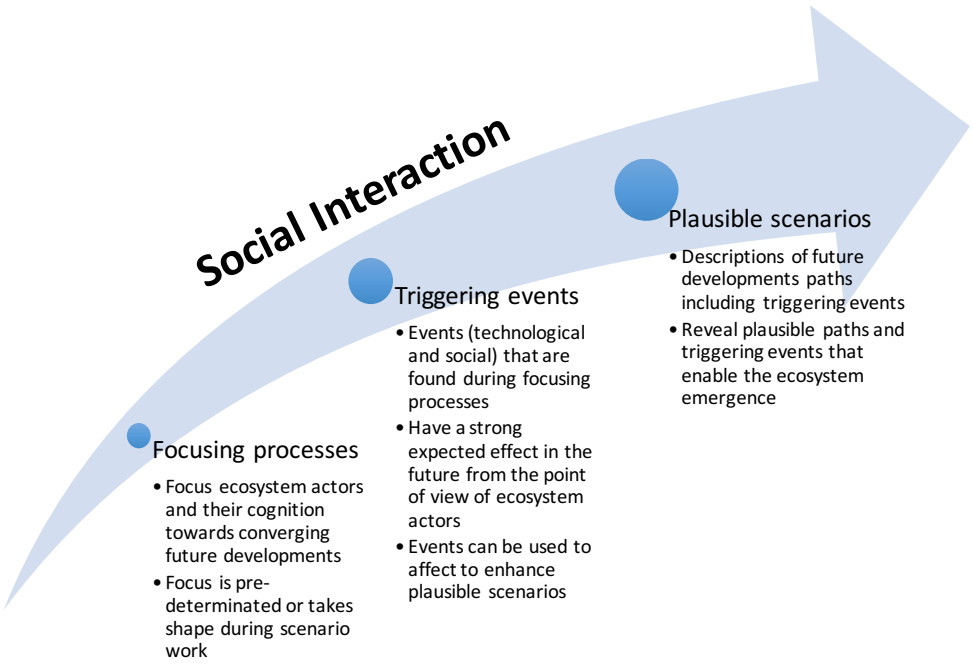

Fig. 1. Process for the scenario work.

4 Emergence of energy service ecosystems research in Finland

Emerging ecosystems in the field of sustainable energy production, energy efficiency, and new services represent one of the feasible areas for scenario use methods. Since the energy sector is currently a subject of political and financial interest in Finland, the topics mentioned above are prominently visible in research programs funded by the Academy of Finland and TEKES (the Finnish Funding Agency for Innovation). These are the two most important state-owned financiers for research and innovation in the Finnish innovation system, and their objective is to create renewal and growth. These programs are introduced here to clarify the background of the three illustrative cases studied in following sections.

In order to foster industrial renewal, political decision makers have recently enforced structural and financial changes within the Finnish innovation system. One of these policy making instruments has been the launching of strategic research initiatives for political decision making and (radical) industrial renewal. As a result of these changes, a new financing body, the Strategic Research Council (SRC) at the Academy of Finland, was established to provide funding for long-term and program-based research aimed at finding solutions to the major challenges facing Finnish society. The most important objectives of

selected SRC programs are to provide support for evidence-based policy; to develop solutions for the regeneration of Finnish society; and to propose ideas for the future of business, industry, and working life. In 2015, the SRC launched programs related to the energy transition in Finnish society *(SET*) and the disruption of digital technologies in industry, including in the energy sector (*DDI*) have started. In addition, the Academy-sponsored project "Change in Business Ecosystems for Local Renewable Energy and Energy Efficiency—Better Energy Services for Consumers (USE)" applies the idea of business ecosystems to a context that extends actor networks from businesses to consumers and public actors.

TEKES strategic research openings are projects seeking to achieve breakthroughs, create new high-level competences, and develop significant new areas of growth in Finland, all in pursuit of a larger goal of fostering the renewal of the Finnish economy. TEKES points out that these projects must have high levels of novelty, including truly new perspectives or unique combinations of topics, and that they need to have the potential to create significant and lasting change in Finnish economy. Furthermore, the visions of these projects must be simultaneously feasible, concrete, and challenging, since the projects will create competences that can be used to achieve goals that may initially seem impossible. The Neo-Carbon Energy project is one of the TEKES strategic research openings. Its objective is to establish a perspective on the needs, business opportunities, and societal implications of an emission-free energy system; to study the connections between the electricity grid and large-scale seasonal energy storage; and to explore its integration with other energy sectors (Landowski, 2014).

One of the recognized key factors in the emergence of energy ecosystems is digitalization, which supports the transformation of an energy system from a centralized system to a more distributed one. This energy transformation is especially visible in Germany, the leading EU country in terms of its use of photovoltaic solar energy systems due to its Energiewende policy (Pegels and Lütkenhorst, 2014; International Energy Agency, 2015). These two factors will provide opportunities for new service development, industry renewal, and, thus, new businesses, which are being studied, with the help of scenario methods, in Academy (SET and DDI) and TEKES-funded projects (Neo-Carbon). These business models can change dramatically as the role of the customer transforms from that of a "consumer" to that of a "prosumer" (Pagani and Aiello, 2010).

For example, in the consumer energy sector, digitalization is now visible through the use of Automatic Meter Readings (AMRs), which allow the remote monitoring of customer energy consumption with one-hour resolution; the use of Nord Pool spot price-based tariffs; and the development of services related to these options. AMRs can be considered physical components of smart grids, providing means for the automated control of active resources, including distributed generation, energy storage, and demand response (DR), which refers to flexibility in energy consumption (Koivisto et al., 2015). A promising service-based example of demand response applications is that of electric heating systems, which may alter their operation according to a given price or frequency signal to allow a required DR to be fulfilled without harm to the end user (There, 2015). AMR also provides technical

infrastructure for other third-party energy services, thus motivating the efficient use of energy and the active management of electric power quality (Logenthiran et al., 2012). -

5 Case projects and the role of the scenario method

Scenario methods are currently applied in three different research projects within the energy sector (see Fig. 2). Of these, TEKES-funded Neo-Carbon Energy first launched with publicly available scenarios in 2014. Academy of Finland-funded projects Smart Energy Transition (SET) and Digital Disruption of Industry (DDI) followed in October 2015. This section introduces each project and its scenario work.

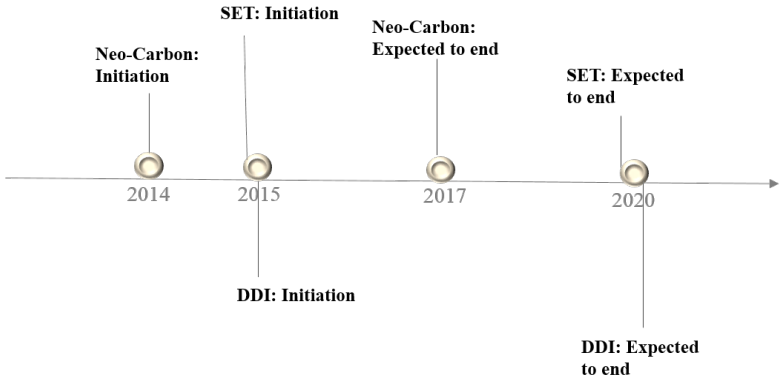

Fig. 2. Timeline of the three projects.

5.1 Neo-Carbon Energy: Scenarios through Futures Cliniques

The Neo-Carbon energy project seeks to design the operation principles and key components of a renewable energy system based solely on wind, solar, and sustainable hydro and biomass. Since the main challenge in solar and wind power is the intermittency of their generation, the key focus lies in seasonal storage solutions and solutions enabling the bridging of the electric power system with other energy systems, such as gas networks, transportation fuels, heat networks, industrial chemicals, etc. The main proposed solution for the energy storage problem is the power-to-gas (P2G) process, through which synthetic natural gas, SNG (i.e. methane), is produced from CO_2 and H_2 during times of excess solar and wind production. The natural gas infrastructure provides nearly infinite storage capacity for chemical energy, and the P2G solution can integrate the different energy systems (heat, power, and transportation).

The aim of the Neo-Carbon Energy project scenarios is to recognize possible radically different energy futures with novel technology solutions and to identify what kinds of businesses these solutions can create. One key question involves how to present the Neo-

Carbon Energy system as attractive to citizens.

In Neo-Carbon, there are four future scenarios for the year 2050 (illustrated in Fig. 3), all of which are transformative. In all scenarios, the world has undergone a third industrial revolution (see Rifkin, 2011), which includes revolutions in both energy production and communication technologies. In each scenario, energy is produced according to the Neo-Carbon energy model; however, the implementation of this solution, as well as people's lifestyles, values, cultures, and business concepts, vary from scenario to scenario (Heinonen et al., 2015).

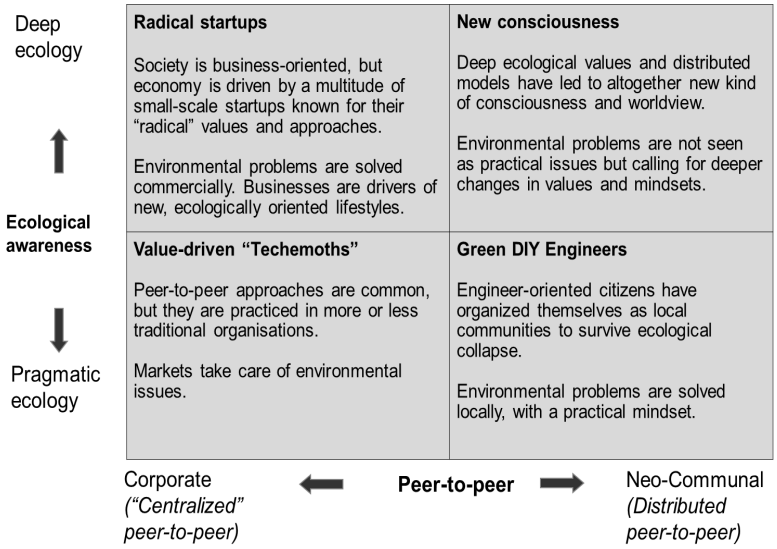

Fig. 3. Four transformative scenarios in the Neo-Carbon Energy project (Heinonen et al., 2015)

Tentative scenarios have been tested in the Futures Clinique (a participatory and exploratory future workshop, which is designed to anticipate especially radical futures and surprising effects [i.e. black swans]; see Heinonen and Ruotsalainen, 2013), during which participants (e.g. project members, government, business, and third sector representatives) work around a variety of scenario sketches. One of the challenges in employing such transformative scenarios, which involve varying socio-cultural aspects, seems to be that they might be overly abstract for primarily technology-oriented experts. However, since these experts were involved in the scenario processing in the Futures Clinique, they were, at least to some extent, committed to the ideas presented. Nevertheless, there is still work to be done to strengthen the links between these future scenarios and technical and economic-oriented research work.

The Neo-Carbon energy project provides benefits for Finnish industry by introducing a novel energy system to leading industrial partners, educating decision makers, supporting

corporate-level strategy development, and identifying concrete business cases. Finally, the project designs and builds prototypes of the selected key technical devices, which the system requires in order to work. During the project, key companies can identify their roles within the energy system value chain and decide how they will subsequently invest in the subject. Ultimately, the project lays the foundations for a novel energy system and enables Finland to lead the transition toward this type of energy system, thus turning it into a business opportunity.

The project's research work is carried out by a multidisciplinary research team from the VTT Technical Research Centre of Finland, Lappeenranta University of Technology and the University of Turku Finland Futures Research Centre. The advisory board comprises industrial partners and provides internal pitching for the project by quarter-annually reviewing the outcomes of the project and directing its work.

5.2 Smart Energy Transition (SET)

Disruptive technologies have been defined as advances that will transform life, business, and, ultimately, the global economy (Manyika et al., 2013). Renewable energy production and storage technologies are potentially disruptive technologies because they change not only the way we produce energy, but also the way we use energy, do business with energy, and innovate. Therefore, smart energy solutions can cascade into new business ecosystems, leading to radical shifts in the roles of producers, service providers, and consumers. The Smart Energy Transition project was launched in October 2015, and analyzes the ongoing global transition and its impacts on Finnish society, including, in particular, the potential benefits for cleantech, digitalization, and the bioeconomy.

The SET consortium consists of seven Finnish universities and research institutes and four other organizations involved in researching and actively facilitating a sustainable smart energy transition in Finland. The work of these actors is divided into six work packages (see Fig. 4), whose progress is advised and accelerated by three expert panels and a transition arena for the demonstration of obtained results.

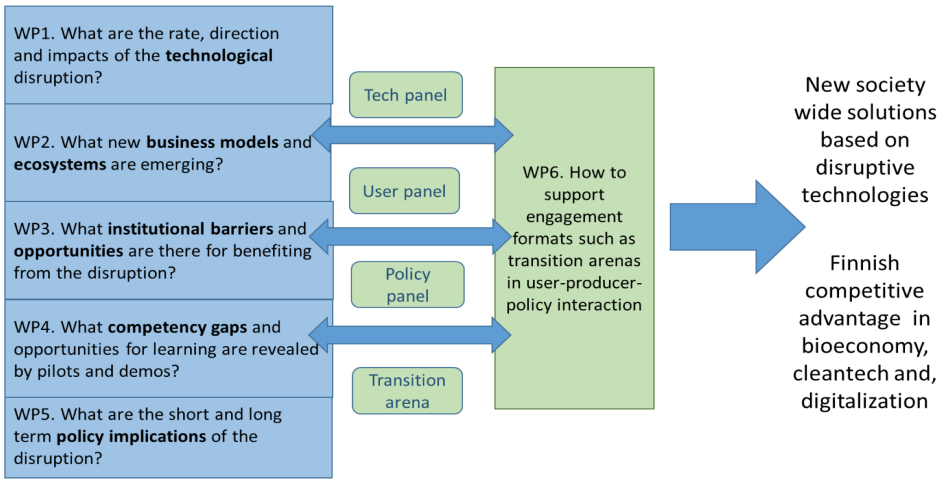

Fig. 4. Description of work packages in the SET project (SET, 2015).

Scenario work is needed in the SET project to clarify the possibilities revealed by disruptions in the energy sector. Compared to the more generic scenario work done in the Neo-Carbon Energy project program, the scenario work in the SET project begins by providing an overall perspective on available solutions to produce, store, and consume renewables-based electrical energy through literature reviews and workshops. Hence, the focus is first on technical aspects. However, once these aspects have been explored and first alternative scenarios are constructed, policies, society, etc. will be considered. Based on the literature review and existing Neo-Carbon scenarios, two alternative scenarios for the year 2030 will be drafted. These will be publicly introduced in workshops and modified according to the results of the Delphi query, which is used to provide input about triggering events related to these scenarios.

5.3 Digital Disruption of Industry (DDI)

The focus of the Digital Disruption of Industry project is on the economic and social implications of this disruption. The DDI project studies how the underlying fabric of current industries—how they operate, how they organize themselves, how they reason about their business and partners, and how they strategize—will be contested when novel digital (institutional) infrastructures with their own rules, norms, and mindsets begin to take form. The project focuses on several sectors of industry from an institutional perspective, which facilitates an evaluation of changes both in the national context and from a broader comparative perspective. The DDI project will yield a comprehensive study of the impact of digitalization, not only to industry itself, but also to its ecosystem partners, its stakeholders, and, more widely, its relevant societal institutions, such as business practices and models, regulation, management, and governance.

The DDI consortium consists of five Finnish universities and research institutes: Aalto, VTT Technical Research Centre of Finland, Lappeenranta University of Technology, ETLA and the University of Turku. This group collaborates with several organizations (large industry, small- and medium-sized enterprises (SMEs), startups and innovators, RTDI actors, government bodies, employees, customers, and consumers) in the targeted industrial and ICT ecosystems. These different actors collaborate in the planning, execution, and assessment of specific interventions related to concrete cases of digital disruption, the challenges involved, and the impacts on stakeholders. Further, within the consortium, there is close interaction with regard to information sharing, interactions with other stakeholders, roadmaps and scenarios, joint publications, events, and action plans for managing the disruption.

The DDI is divided into five research work areas, which simultaneously tackle the two overall objectives of the project: the research objective of synthesizing an increasingly expressive scientific understanding of digital societal disruption, as seen through the lens of industry, and the policy objectives of creating an effective policy response to the institutional challenges raised by this disruption and of charting a route for Finnish companies and society through this change. The scenario process in DDI serves as a tool for active dialogue and interactions among policy, research, industry, and citizens, and this shared awareness creates the foundation for the research project. The scenario method will be used throughout the project to continuously analyze the context of digital disruption and industry transformation. Meta-scenarios will be used to identify the main driving forces of the operative environment, as well as the triggers beyond the shared cognitive frames that inform changes in future development paths. Further, the created meta-scenarios will provide normative descriptions of the uncertainties related to technology development, economic and social factors, and regulative and political actions for the next 15 years.

6 Focusing processes and triggering events in the case projects

As described in the earlier focusing processes, social interactions and triggering events represent essential elements and outputs of scenario work. Focusing processes include events in which the different parties and their ways of thinking can be directed towards possible future paths. These enable the various actors to engage in vivid discussions and challenge possible future scenarios. Through these interactions, actors create a common understanding and a shared vision of the future. A trigger can represent an issue or event that is expected to "trigger" a chain of events or a future path to the future. Triggering events can either inspire or occur during scenario work, but in both cases, these events attract the interest of various parties to engage in the scenario work in order to prepare for the future.

In the case of the Neo-Carbon Energy project, specific scenario work has already been performed, and in the SET and the DDI, the scenario work is ongoing. The SET and Neo-Carbon Energy projects are highly interlinked, since the SET builds upon the initial results of the Neo-Carbon project's scenario work (see also Fig. 2 and the discussion above). These

two projects are more technologically oriented, with DDI taking a broader and more business-oriented perspective by focusing on multiple interconnected industries, including energy. Table 1 provides examples of focusing and triggering events for the scenario work in the Neo-Carbon Energy project, as well as for the planned and/or initial scenario work in the SET and DDI projects. The data resulting from the scenario work and the use of Delphi queries (see e.g. Glenn and Gordon, 2009) will reveal more detailed triggering events, such as abrupt changes in the energy production system.

Table 1. Illustrative examples of focusing processes and triggering events in case projects

Case project	Role of scenario methods	Focusing processes utilized/to be utilized	Triggering events identified
Neo-Carbon	To provide insights into how the future RES-based energy world might be realized in four radically different transformative ways.	Futures Clinique; different foresight methods (e.g. Futures Window, identification and impact analyses of weak signals and black swans, scenario narratives, etc.).	Increasing peer-to-peer approaches, prosumerism, ecological awareness, the boom of startups with open-source principles, the increasing dominance of technological giants, and ubiquitous ICT.
Smart Energy Transition consortium (SET)	To provide an understanding of the rate and direction of energy transformation towards the selected scenarios	Workshops with project partners; Delphi study with expert panels (tech, users, policy) for determining possible triggering events in the assumed scenarios.	First workshop results: new startups and export companies, scarcity of resources, ecological disasters
Digital Disruption of Industry (DDI)	To enable active dialogue and interactions among the different actors of the wider energy ecosystem.	Workshops with expert panel discussions; scenario work through the workshops; utilization of SET project Delphi study results applicable to this project.	First ideas based on expert discussions: the shift in the Internet of Things from hype to reality as a techno-economic-social disruption that is expected to significantly influence the relative competitiveness of firms and nations.

The scenario methods in the case projects serve as tools for fostering active dialogue and interactions among the various actors involved in the energy sector (e.g. policy makers, research institutions, companies, entrepreneurs, and even citizens). First, through the scenario work in the case projects, the different stakeholders can jointly recognize the driving forces and alternative future paths of the energy sector. In practice, the interested and relevant parties are invited in workshops and participative, facilitated discussions, through which they become aware and share their views of the nature and impact of future

developments in the energy sector, which then mobilize them to take an active role, work together, and build the necessary synergies in the planning, execution, and assessment of specific actions to respond or influence these developments. The scenario methods enable social interactions among different actors in, for example, sharing information and knowledge, building joint roadmaps, and generally co-creating effective joint responses (e.g. improving current networked processes or building new business models) to the uncertainties of energy technology development, as well as other economic, social, regulative, and political factors. The strategic research programs set by policy makers provide the incentive for and expectation that various stakeholders set up scenario processes that will enable them to learn about one another and the potential futures of the energy sector through social interaction. In this way, the scenario process can become a focal mechanism for the emergence and birth of interdependent ecosystem(s) with shared goals, visions, and purposes.

7 Conclusions

This paper has discussed the emergence of new ecosystems in the area of energy services from a public policy perspective. We have developed a view of scenario methods as mechanisms that help to focus the attention of potential and current actors, as well as to create visibility for triggering events that are leading future developments. In so doing, our paper answers recent calls to better understand how public policy can help the creation of business and innovation ecosystems (Clarysse et al., 2014), as well as the birth and emergence of ecosystems in general (Ritala et al., 2013). The results suggest a range of research, policy, and practical implications, which are discussed in the following.

7.1 Research implications

Our study contributes to the research on ecosystem emergence in general and provides implications for policy research in the field of energy services.

First, as we discussed in the beginning of the study, ecosystem emergence is among the most important, but least studied phenomena within business and innovation ecosystem literature. Our papers suggest that facilitating the emergence of ecosystems might be necessary when self-organizing is not progressing sufficiently quickly. Ecosystem coordination is often managed by a strong focal actor (see e.g. Moore, 1993; Iyer and Davenport, 2008; Isckia, 2009; Rohrbeck et al., 2009); however, in the absence of such an actor, other mechanisms become useful in enabling the emergence and growth of ecosystems. This also highlights the essential linkages between the literatures of business and innovation ecosystems and public policy research streams, such as the research on triple-helix and national innovation systems (e.g. Martin and Johnston, 1999; Etzkowitz and Leydesdorff, 2000). Since business and innovation ecosystems are complex systems with open boundaries and constant inflows and outflows (Cilliers, 2001), the interdependencies and co-evolutions between public policy and private sector actors is an issue that is relevant

for practically any study related to emerging technologies and innovations.

Second, it has been suggested that research programs, as policy making instruments, play an important role in the creation and exchange of knowledge among participating actors (Autio et al., 2008). In this study, we have argued that scenario workshops provide the time and space for ecosystem actors to share explicit and tacit knowledge. The role of these workshops is further accentuated in situations in which businesses do not yet see concrete business opportunities and when capturing the benefits of these opportunities requires the learning and development of competences among various ecosystem actors. Especially in the highly regulated energy industry, individual actors may not have sufficient incentive to take risks, take on ecosystem leadership roles, or invest in the building of ecosystems for new energy services (Iansiti and Levien, 2004). Thus, we argue that scenario work is a usable approach to study the future of emerging energy service systems.

7.2 Policy and practical implications

In the Finnish new energy services context, there is no clear focal actor, single technology, or technology platform. This is also the case for many emerging technologies, which tend to face the "chicken and egg" problem. To overcome the chasms among initiative-taking, followership, and concrete actions, research programs and scenario work can be seen as especially helpful. Strategic research programs implemented by policy makers can be seen as (knowledge) platforms for connecting various ecosystem actors, since they build interdependence and require some level of coordination. Here, the recurrent interactions among knowledgeable and resourceful actors enabled by scenario work and related process can trigger the emergence of a more concrete ecosystem, which will begin to self-organize towards plausible future scenarios.

In our research, we not only illustrate the use of the scenario method as a focusing and triggering mechanism for a single strategic research program, but also show the importance of the knowledge sharing mechanisms that link different strategic research programs. Each strategic research program has a specific focus, which may not be sufficient, on its own, to turn individual research and development collaborations into a concrete ecosystem. Rather, the knowledge sharing mechanisms function as linking mechanisms that connect complementary research programs to a larger knowledge ecosystem (Clarysse et al., 2014). Yet, without the scenario method and process as a focusing and triggering mechanism, the system could suffer from inertia and fail to realize its potential. Our results highlight the potential benefits of scenario work in this regard.

7.3 Limitations and future research directions

This paper has limitations, especially regarding its generalizability. The case evidence presented in this paper should be treated as illustrative, since its purpose is to showcase the potential usage of scenario methods in the energy services sector context, rather than to prove cause-and-effect relationships. For instance, the SET and DDI research projects are still nascent; thus, their outcomes should be seen as plans for the actual scenario work to be

carried out. Overall, we have revealed the very first results of the scenario work.

Future studies may build on the ideas presented on this paper in several ways. First, there is a need for studies to understand how scenario methods can facilitate ecosystem emergence. Our conceptualization of focusing processes and triggering events could serve as a foundation for conducting more data-rich case studies or broader quantitative studies. Second, more context-aware studies are needed to understand how energy sector actors, in particular, organize within ecosystems. Since many of the major global challenges are related to renewable energy, we need to know more about how business and innovation ecosystems are built around these challenges and what public policy can do to facilitate this development.

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Antecedents of organizational creativity: drivers, barriers or both?[1]

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Abstract. This paper reviews academic journal articles and scholarly books focusing on organizational creativity and constructs a schematic representation of the antecedents of organizational creativity, i.e. of the associated drivers and barriers. The literature on organizational creativity is reviewed using a traditional review technique. The focus is especially on more recent developments of the discourse, and therefore this work can be labeled as a state-of-the-art review. The review shows that drivers have clearly been studied more extensively than barriers. It was also recognized that the predominant approach among organizational creativity scholars is to dichotomize the factors influencing organizational creativity, more specifically to discuss the antecedents of creativity mostly from the viewpoint of drivers. In some cases, the antecedents are discussed from the perspective of barriers, but only rarely has it been recognized that the very same factor may either enhance or inhibit creativity. In this paper, such factors are called 'either-or factors'. The paper suggests that the organizational creativity discourse should acknowledge that it is not enough to understand what enhances organizational creativity but also which kind of issues inhibit it and, especially, which factors may work either against or toward creativity under different circumstances. The review suggests that the majority of factors are most likely either-or by nature, although it has been overlooked in the discourse due to the dichotomizing tendency.

Keywords. *Organizational Creativity, Organization Studies, Creativity, Literature Review*.

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1 Introduction and purpose of paper

Fierce competition, the turbulent economic situation and a greater speed of change have made creativity a highly sought-after capability for business organizations. Instead of relying on long-range strategies, organizations need to be able to anticipate and react to fast changes and take advantage of the unknown. Therefore, it is not enough for organizations to recruit creative individuals; instead the whole organization needs to be adaptive, flexible and innovative. These requirements have brought the notion of 'organizational creativity' to the centre of managerial interests in the past few years. Along the increase in managerial interest, organizational creativity has increasingly attracted the interest of scholars from several different social sciences fields. In fact, a simple search via Scopus (www.elsevier.com) showed that the number of peer-reviewed studies mentioning 'organizational creativity' in all search fields was 31 in 1990, 357 in 2000, and 2,430 in 2010 (see Appendix 1). Organizational creativity is thus emerging as a distinct area of academic inquiry, although the speed of emergence of new publications hints at the potential danger of fragmentation. There is thus a need for studies synthesizing current knowledge. Among the few existing examples is Andriopoulos' (2001) article 'Determinants of organizational creativity: a literature review,' which has been cited widely. Although this study was a useful attempt toward reviewing the drivers of organizational creativity, it is quite clearly outdated as a literature review, especially considering the pace of academic publishing on the topic over the last fifteen years.

More recently, Klijn and Tomic (2010) analyzed the factors that could be considered drivers of organizational creativity and surveyed major creativity models, mediators, and enhancers from a psychological perspective. This paper focuses explicitly on what the authors call enhancers, i.e., drivers, however our analysis is not constrained to the psychological perspective. In addition, unlike Klijn and Tomic (2010), this paper reviews not only the drivers of but also the barriers hindering organizational creativity. A few years later, Anderson et al.'s (2014) state-of-the-science review on creativity and innovation in organizations proposed a guiding framework for future research in the domain. Anderson et al.'s (2014) review covered a wide range of drivers of organizational creativity although its coverage of barriers to organizational creativity was not equally extensive. The extensive coverage of drivers and a very scarce interest in barriers is even more notable in the case of empirical studies on organizational creativity. This trend could be reflective of an optimistic belief that by adding in enough drivers, organizational creativity is enhanced. This is, however, not the case because even only one barrier to creativity, for instance a constant lack of time, may very effectively inhibit creativity, even in the presence of many drivers. The so-called positivity–negativity asymmetry effect, which refers to the human tendency to be more strongly influenced by negative events than by positive ones, exists in almost all psychological domains such as social relationships, emotions, and learning (Baumeister et al., 2001). Similarly, a single or a few barriers to organizational creativity are likely to cast an effect that can overcome the influence of several drivers. Moreover, several of the barriers to organizational creativity are related to factors that necessarily exist in an organization, such as climate, leadership, or time pressures, and inevitably work either against or toward creativity. Therefore,

to complement the current knowledge on determinants of organizational creativity, this paper proposes that a more thorough understanding of the drivers of and, especially, the barriers to organizational creativity is needed. Moreover, to overcome the optimistic focus on drivers in finding ways to enhance creativity, a more elaborated perspective on the understanding of the antecedents of organizational creativity is provided.

Thus, the purpose of this paper is to review the antecedents of organizational creativity as presented in academic journal articles and scholarly books and deepen the theoretical understanding of the nature of antecedents of organizational creativity. First, organizational creativity as a topic of study is introduced and a few basic models of organizational creativity are briefly described. Second, the paper elaborates on the antecedents of organizational creativity identified in the reviewed studies. Then a theoretical perspective is taken and it is discussed how antecedents, i.e., drivers and barriers, of organizational creativity are typically theorized in the organizational creativity discourse [1]. It is suggested that instead of showing excessive interest in the drivers of organizational creativity, it should be recognized that many, if not most, of the factors might in fact act as drivers or barriers depending on the context and situation. We call the factors, which can have either enhancing or inhibiting influences on creativity, as either-or factors and conclude that the organizational creativity discourse should acknowledge that it is not enough to know and understand what enhances organizational creativity but also which kind of issues inhibit it and, especially, which factors may work either against or toward creativity under different circumstances. Finally, the conclusions are presented and the findings and limitations discussed.

2 Organizational creativity as a topic of study

Themes related to creativity have been studied systematically ever since the 1950s. The foci of creativity related studies have been on individual-centered psychometric perspectives, while the social and organizational designs and settings where creativity takes place have received much less attention. Authors interested in these social settings see the domination of individual perspectives as an important limitation (see, e.g., Styhre and Sundgren, 2005; Shalley and Zhou, 2008). Consequently, creativity scholars such as Csikszentmihalyi (1994) urge the need for widening the scope of what is perceived as the process of creativity. Specifically, Csikszentmihalyi (1994(suggests adopting a systemic perspective that includes not just the individual but also the cultural and social contexts.

Within organizational studies, creativity has been recognized as an important organizational element in several seminal works (see, e.g., Mintzberg, 1979; Morgan, 1986). However, while these classic studies recognize the importance of creativity per se, they nevertheless perceive it only as one factor among others. Therefore, as Sundgren and Styhre (2007, p. 219) have put it, “an important step in understanding creativity in an organizational context is to take a more holistic approach and use the concept of organizational creativity.” What distinguishes organizational creativity research from general creativity research is that it is not interested in creativity in the

arts, short-term problem-solving tasks conducted in behavioral laboratories, children's creativity, or helping individuals to think more creatively, etc. (cf. Shalley and Zhou, 2008, p. 3–4). It is interested in creativity in the context of a work organization and leans on an understanding of creativity as a broader phenomenon than simply as an individual thought process. It seems that the majority of scholars contributing to the organizational creativity discourse share a general understanding of the definition of the very phenomenon itself. This predominant definition is the one presented by Woodman et al. (1993, p. 293), who define organizational creativity as "the creation of a valuable, useful new product, service, idea, procedure, or process by individuals working together in a complex social system."

Usually, innovation and creativity are considered to be closely related and, sometimes, the concepts are even used interchangeably (see, e.g., Amar and Juneja, 2008). A widely agreed upon view distinguishes creativity from innovation in that creativity refers to production of ideas, whereas innovation refers to the successful implementation of ideas (Amabile, 1996; McLean, 2005). The relevance of organizational creativity studies is often justified in terms of it acting as a precursor for innovation (see. e.g., Amabile et al., 1996; Styhre and Sundgren, 2005), and this paper takes a similar stance. Although there are only few empirical studies on the relationship between creativity and innovation (see, e.g., Mohamed and Rickards, 1996; Bharadwaj and Menon, 2000; Sohn and Jung, 2010), it has been found that a creative climate (Mohamed and Rickards, 1996; Sohn and Jung, 2010) and formal creativity-enhancing approaches and structures (Bharadwaj and Menon, 2000) contribute to the innovation performance of a firm. However, in this paper, the interest is primarily in organizational creativity itself, and therefore, the literature on innovation and organizational innovation (see Crossan and Apaydin, 2010 for a review) has not been included in the review. Moreover, this paper leans on a broader conceptualization of organizational creativity (Woodman et al., 1993) instead of seeing it only as the production or generation of ideas (cf. Amabile, 1996).

According to Shalley and Zhou (2008), the two main theoretical models of organizational creativity are the componential model created by Amabile (e.g., 1988) and the interactionist model of Woodman et al. (1993). According to Amabile's (e.g., 1988) componential model of creativity, creativity takes place at the intersection of expertise or domain-specific skills, motivation, and creative thinking skills. Amabile (1983; 1988; 1996; 1997) was among the first scholars who attempted to widen the scope of creativity research from the individual level to the social level and, eventually, to the organizational level. In a similar vein, Woodman et al. (1993) proposed one of the first multilevel models by linking individual-, group-, and organization-level variables to creative outcomes. Both the componential and the interactionist models explore the multidimensional nature of organizational creativity. To elaborate further, the models of Amabile (1983; 1988; 1996; 1997) and Woodman et al. (1993) illustrate that individual creativity is a complex phenomenon influenced by multiple individual-level factors, as well as contextual and environmental factors. Even though both models stress the role of contextual factors at different levels, Woodman et al.'s (1993) model emphasizes on the interaction between the person and the situation and, importantly, on various influences across levels.

Cross-level influences on creativity are essential in identifying the attributes that

enhance or constrain organizational creativity. The interactionist model investigates creativity at different levels with social and contextual influences. For example, individual characteristics such as cognitive abilities, personality, and motivation are defined as factors. Group characteristics such as size, diversity, roles, cohesiveness, and problem solving are group-level determinants of organizational creativity. Lastly, organization characteristics such as culture, resources, and strategies are presented as examples of organization-level influences (Woodman et al., 1993). Overall, the model is based on the notion that creative individuals, groups, and organizations are inputs that are transformed in various ways by the process and the situation, which includes both drivers of and barriers to creativity at all levels of analysis (Woodman et al., 1993). In this paper, the idea set forth by Woodman et al. (1993) is adopted in pursuing to analysis of the antecedents of organizational creativity.

3 Data collection and analysis

This paper reviews the fast growing body of literature on organizational creativity using a traditional review technique and focusing on articles published during or after 2000 (Jesson et al., 2011), complemented with a snowballing technique (Ridley, 2012) to track studies that were published prior to 2000 but were widely cited and thus relevant to the field. A special emphasis is put on more recent developments of the discourse, as it was around the year 2000, when the interest in organizational creativity started to grow notably (see Appendix 1). Thus, this work can be labeled as a state-of-the-art review, the purpose of which is to provide a contemporary, comprehensive overview of a particular topic (see Jesson et al., 2011; Lucarelli and Berg, 2011). In this case, it enables to focus particularly on studies published after Andriopoulos's (2001) widely cited review and, thus, to concentrate on more recent developments in the discourse, while still taking into account some older, yet influential studies.

In August and September 2014, a search of three electronic databases [2] was conducted to search for journal articles dealing with organizational creativity. The search phrase benchmarked from Blomberg (2014) was 'organi?atio* AND creativity' [3]. The search focused on peer-reviewed, scholarly articles published between January 2000 and September 2014. The abstracts of the articles gathered in the search were read by two authors of the paper to decide whether they actually discussed organizational creativity, and those that did were read in full. To complement the database search, a snowballing technique (Ridley, 2012) was used to track older articles (published prior to 2000) that are widely cited and, thus, relevant to the field but not included in the database search. They were included in the review because they were considered central to the understanding and development of the research domain.

When reading and analyzing the material, a thematic analysis was applied. A theme represents a patterned meaning within the empirical material and reveals something relevant to the research question (Braun & Clarke 2006). Thus, thematization allows for meaningful, systematic, and rigorous interpretation of collected data (Saunders et al., 2003). The analysis proceeded in the following way: First, the material was

carefully read and commonly recurring themes related to antecedents of organizational creativity were identified through a pattern-matching technique. Second, the themes were revised to make sure there was enough material to support them. Next, the formed themes were classed into four levels of analysis based on Woodman et al.'s (1993) study of organizational creativity, which was used by Anderson et al. (2014) as well in their review. Consequently, the analysis is divided into the following levels: i) individual, ii) group/team, iii) organization, and iv) macro [4]. Lastly, we identified inconsistencies and gaps in the extant literature concerning antecedents of organizational creativity.

4 Drivers and barriers in organizational creativity

In this section, the recognized drivers of and barriers to organizational creativity are explicated on four levels: individual, group, organization and macro. The subsections follow the same order. Each level is further divided to cover the individual themes formulated during the pattern-matching process, and each theme comprises individual factors.

Scholars have found several attributes that facilitate organizational creativity (drivers) on all levels of analysis, but they have paid much less attention to the barriers. The following subsections cover the major themes on the abovementioned four levels, as identified in the reviewed articles. Studies focusing on the individual, group, or macro level are much fewer in number than those concentrating on the organizational level. A relatively large number of studies focus on multiple levels simultaneously, for instance, on the group and organizational levels. Nevertheless, it was possible to position the factors discussed in these articles in terms of the four specific levels. In general, the levels of analysis are relatively explicit, but some themes and factors do overlap slightly.

4.1 Individual level

Organizations and groups comprise individuals, and therefore, individual creativity is often considered the basic element of organizational creativity. Thus, it is somewhat surprising that fewer studies focus specifically on the individual level than on organizational level. Individual creativity has been studied exhaustively in earlier studies on creativity, and is therefore no longer considered to be of great interest, as several authors (see Björkman, 2004; Klijn and Tomic, 2010; De Stobbeleir et al., 2011) have pointed out. However, four major themes covering the individual aspect of organizational creativity were identified in the reviewed articles: i) 'self-management' factors such as self-efficacy, self-regulation, and self-concordant goals, ii) motivation, iii) mood and affect, iv) knowledge, knowledge acquisition and its accumulation through workshops, feedback, and internal/external relationships, for example. These themes are explicated below.

The first theme covers what can be called *self-management factors* and their effect on creative performance. The terms used in the studies include self-efficacy, self-esteem, self-regulation, creative identity, and self-concordant goals, which have been found to have a positive link with creative outcomes (see Axtell et al., 2000; Tierney and

Farmer, 2002, 2011; Chong and Ma, 2010; De Stobbeleir et al., 2011; Ejaz et al., 2011; Mathisen, 2011; Richter et al., 2012). In other words, a strong belief in one's own actions and creative capability is positively related to individual creativity, whereas low self-esteem and self-censorship may inhibit individual creativity (Williams, 2002). The fact that self-management factors are considered an important driver of organizational creativity highlights the importance of giving employees a role that is autonomous and carries enough responsibility to facilitate self-management (Axtell et al., 2000). These self-management factors are also connected to the second theme, motivation.

Intrinsic *motivation* is traditionally recognized as an important element of creativity, whereas extrinsic rewards are found to be detrimental to creativity (Amabile, 1983; Baer et al., 2003). The role of extrinsic motivation, and especially achieving the right combination of intrinsic and extrinsic motivation was discussed in the reviewed studies (see, e.g., Mumford, 2000; Baer et al., 2003; McLean, 2005; Sundgren, Selart et al., 2005, Griffin et al., 2009). Put in other words, there is a general agreement that intrinsic motivation is a necessary driver of creativity, and extrinsic rewards are usually considered as barriers to creativity (Amabile, 1983). However, in the reviewed articles, extrinsic rewards and extrinsic motivation were widely discussed from the viewpoint of being drivers (Mumford, 2000; Walton, 2003; Sundgren, Selart et al., 2005; McLean, 2005; Griffin et al., 2009), in that for instance, informative feedback and evaluation actually increase intrinsic motivation and creativity (Zhou, 1998; Sundgren, Selart et al., 2005). Thus, there is general agreement that motivation is a significant factor, but there are varying views on the roles and the right balance of intrinsic and extrinsic motivation and their influence on creativity.

The third theme to emerge was *mood or affect*, referring to both emotion and mood. Positive affect has been found to enhance individual creativity (see Amabile et al., 2005; Adler and Obstfeld, 2007; Klijn and Tomic, 2010; Baron and Tang, 2011). Affect influences the creative process in three ways. First, it is integrally linked with motivation. Second, creativity is particularly susceptible to affective influences due to the cognitive variations that stimulate it. (Amabile et al., 2005.) Third, individuals typically recall mood-congruent information, and more information tends to be recalled during a good mood (Walton, 2003; Elsbach and Hargadon, 2006). Some scholars argue that there may be a link between negative affect and creativity (e.g., George and Zhou, 2002; 2007), but their results are less consistent than in the case of positive affect (Amabile et al., 2005; Klijn and Tomic, 2010). A negative mood in general can be considered as a barrier to creativity (Amabile et al., 2005), although Elsbach and Hargadon (2006), for instance, argue that it may also work as a driver when employees perceive that creativity is recognized and rewarded in their organization. Elsbach and Hargadon (2006) further suggest that negative affect may serve to motivate creative work when workload pressures are low, but when the pressure is high, positive affect may be required to stimulate the flow of creative thoughts.

The fourth theme, *knowledge* and experience of the field are typically perceived as necessary preconditions for creativity (see, e.g., Amabile, 1996; Weisberg, 1999; Mumford, 2000; Egan, 2005; Sundgren and Styhre, 2007). Several scholars discuss different ways of accumulating knowledge, such as workshops (e.g., Birdi, 2005),

feedback (e.g., De Stobbeleir et al., 2011; Zhou and George, 2001), and internal/external relationships (e.g., Madjar, 2005; 2008; Perry-Smith, 2006). However, previous knowledge may also inhibit organizational creativity in terms of causing fixedness and rigidity in an individual's thinking (Woodman et al., 1993; Klijn and Tomic, 2010) or as it may result in more habitual thinking (Ford, 1996).

4.2 Group level

Even fewer articles focus explicitly on the group level of organizational creativity than on the individual level. However, four major themes emerged: i) diversity, ii) group management, iii) group climate and culture, and iv) creativity-enhancing techniques.

The first theme, *diversity* covers the skills, functional or hierarchical positions, knowledge, and background of the group members (see, e.g., Walton, 2003; Egan, 2005; Bunduchi, 2009; Burbiel, 2009; Hemlin, 2009; Andriopoulos and Lewis, 2010; Yoon et al., 2010; Richter et al., 2012). Groups rich in diversity have been found to be more creative, whereas homogeneous groups, whose members possess overlapping skills, are less likely to develop creative ideas. Diversity can, however, also negatively influence creativity. In some cases, it causes misinterpretation of other participants' ideas, which is a risk, especially in the virtual team context. Geographic dispersion, too, can exacerbate the group members' differences and cause feelings of isolation or disappointment (Chamakiotis et al., 2013.)

The second theme, *group management*, includes factors such as the group's self-management (Axtell et al., 2000; Isaksen and Lauer, 2002; Kylén and Shani, 2002; Björkman, 2004), group leadership (Hemlin, 2009; Chamakiotis et al., 2013), organizational encouragement (Castiglione, 2008; Hemlin, 2009), support for innovation (Axtell et al., 2000; Hemlin, 2009), and feedback (Zhou and George, 2001; Hemlin, 2009). Group management implies that the group should be able to manage itself effectively, whereas organization-level management should be appropriate in terms of allowing and facilitating the group's work. Potential barriers to creativity here are the dominance of some members, which may reduce other members' creativity (Chamakiotis et al., 2013).

The third theme, creativity-enhancing *group culture and climate*, requires the group members to trust each other (Andriopoulos, 2001; Sadi and Al-Dubaisi, 2008; Hemlin, 2009); communicate well in the group (Andriopoulos, 2001; Al-Beraidi and Rickards, 2003; Egan, 2005; Sadi and Al-Dubaisi, 2008; Hemlin, 2009; Misra, 2011); have a sense of belonging, cohesiveness, and commitment (Al-Beraidi and Rickards, 2003; Egan, 2005; Hemlin, 2009; Misra, 2011); and have a positive attitude toward other group members (Egan, 2005). It is equally important to have clear objectives for group work (Al-Beraidi and Rickards, 2003; Egan, 2005), an open environment (e.g., Andriopoulos, 2001; Hemlin, 2009), a supportive learning culture (Thompson 2003; Yoon et al. 2010), psychological safety (Andriopoulos, 2001; Hemlin, 2009; Kessel et al., 2012), and shared vision and goals (Al-Beraidi and Rickards, 2003). Creativity is enhanced naturally if group members are motivated (Amabile, 1983), but, additionally, adequate pressure and demand are needed to spark the motivation of the team (West, 2004; Hemlin, 2009). Furthermore, a climate that allows productive

conflict between group members is a driver of group creativity (Egan, 2005; Isaksen and Ekvall, 2010; He et al., 2014). However, too much disagreement or need for conformity, or the wrong kind of conflict may act as a barrier (Pech, 2001; Egan, 2005; Isaksen and Ekvall, 2010; He et al., 2014). Other factors that potentially block creative group climate include negative attitudes, a controlling or constraining environment, lack of psychological safety, and time or expectation pressures (Amabile, 1996; Egan, 2005; Kessel et al., 2012).

The fourth theme, *creativity-enhancing techniques*, has been covered extensively. It differs from the three previous themes in that it focuses mostly on creativity understood as the generation of ideas and multiple perspectives, whereas the other three themes focus on creativity more broadly. Brainstorming (see McFadzean, 2000; Al-Beraidi and Rickards, 2003; Thompson, 2003; Walton, 2003; Egan, 2005; Litchfield, 2008) in particular is discussed widely and is generally used to generate ideas and multiple perspectives from multiple members (Thompson, 2003; Egan, 2005). However, Walton (2003), Egan (2005) and Elsbach and Hargadon (2006) argue that brainstorming does not always produce favorable outcomes and that the sessions are not necessarily effective at yielding creative outputs. Despite the related problems, however, most participants in brainstorming sessions generally believe it to be a very effective strategy for enhancing group creativity (Egan, 2005). Few other creativity-enhancing techniques were also discussed, such as lateral thinking (Butler, 2010) and creative problem solving techniques (McFadzean, 2000). Some scholars suggest that ideation would benefit from ready-made templates or structures, concluding that structure-consistent ideas outperform random ideas in terms of their creativeness (Goldenberg and Mazursky, 2008).

4.3 Organization level

Organization-level creativity has received the most interest compared to the individual, group, and macro levels. Moreover, organization-level factors are discussed in several articles dealing with multiple levels in the same analysis. Therefore, it is only natural that views pertaining to the organizational level of creativity are the most diverse. At the organizational level, the following themes emerged: i) management and leadership, ii) knowledge, iii) resources, iv) structure and systems, v) spatial/physical dimensions, and vi) organizational culture and climate.

The first theme, *management and leadership*, associated with enhancing creativity, is one of the most common themes in the reviewed articles. Management-related factors influencing organizational creativity include providing employees with sufficient freedom and autonomy (Daymon, 2000; Mumford, 2000; Sundgren, Selart et al., 2005; Moultrie and Young, 2009; Andersen and Kragh, 2015), appropriate resources (Epstein et al., 2013), job design (Elsbach and Hargadon, 2006; Amar and Juneja, 2008), supervisory support (e.g., Sundgren, Selart et al., 2005; Wang and Casimir, 2007; DiLiello and Houghton, 2008; Andersen and Kragh, 2015;), establishing creativity-enhancing cultural practices (Isaksen and Ekvall, 2010; Epstein et al., 2013), and coping with paradoxes related to managing creativity (Andriopoulos and

Lewis, 2010; Knight and Harvey, 2015). For instance, managers are required to encourage individuals to think outside the box, while simultaneously maintaining a shared direction for the creative work (Andersen and Kragh, 2015). Although freedom and autonomy were discussed mostly from the viewpoint of being drivers (Amabile, 1997; Daymon, 2000; Sundgren, Selart et al., 2005;), it was noted that finding a suitable balance between freedom and control depending on the task is important because too much freedom and autonomy may become a barrier to creativity (Mumford, 2000; Bunduchi, 2009).

Numerous articles focus also on leadership and, specifically, leadership styles (see, e.g., Andersen, 2000; Farmer et al., 2003; Sundgren, Selart et al., 2005; Politis, 2005; Wang and Casimir, 2007; Pryor et al., 2010). Transformational (Al-Beraidi and Rickards, 2003; Shin and Zhou, 2003; Wang and Rode, 2010) or participative and democratic (Andriopoulos, 2001; Somech, 2006; Mathisen et al., 2012) leadership styles are important drivers of organizational creativity because leadership style encourages employee creativity directly and influences the climate and culture of an organization, especially in small organizations (Somech, 2006; Mathisen et al., 2012). However, there is empirical evidence that this applies to Western cultures, whereas in Asian cultures, a more authoritative leadership style is needed to enhance creativity (Zhou and Su, 2010). Moreover, the leader's emotional intelligence was found to be conducive to employee creativity (Zhou and George, 2003; Rego et al., 2007; Castro et al., 2012). Although leadership- and management-related issues were mostly discussed as drivers of creativity in the reviewed articles, it can be assumed that management and leadership styles that fail to fulfill the aforementioned criteria would act as a potential barrier to creativity. The studies mentioned that a management that promotes people who conform to the organization's traditions and behave in ways considered appropriate could inhibit creativity because this kind of leadership encourages conformity rather than creativity (Pech, 2001).

Organization-level *knowledge* is the second theme, covering aspects such as organizational learning, which refers to the organization's capability and willingness to learn and acquire new knowledge (see, e.g., Borghini, 2005; Basadur and Gelade, 2006; Amar and Juneja, 2008; Tajeddini, 2009; Shahin and Zeinali, 2010) knowledge combination (see, e.g., Umemoto et al., 2004; Borghini, 2005; Sundgren and Styhre, 2007); and cross-fertilization of knowledge (see, e.g., Umemoto et al., 2004 McLean, 2005; Madjar and Ortiz-Walters, 2008; Mahmoud-Jouini and Charue-Duboc, 2008). Although knowledge is a crucial element of organizational creativity, it may be a barrier in some cases (Sundgren, Dimenäs et al., 2005; Mahmoud-Jouini and Charue-Duboc, 2008): as a form of power in an organization, knowledge is not shared easily.

It is commonly agreed that the production of creative outputs requires sufficient *resources* such as time and money (see, e.g., Andriopoulos and Gotsi, 2000; Andriopoulos, 2001; Barrett et al., 2005), which comprise the third theme. It should be noted that sufficiency enhances creativity, but excess may lead to inefficiency (Mumford, 2000; Bunduchi, 2009). Insufficient resources in terms of time, funds, and expertise constitute a common barrier to creativity (e.g., Sadi and Al-Dubaisi, 2008). Moreover, excessive workload pressure is a common barrier to creativity (Amabile, 1996; Hemlin, 2009).

The fourth theme covers an organization's *structure and systems* (see, e.g.,

Andriopoulos and Gotsi, 2000; Andriopoulos, 2001; Martins & Terblanche 2003; Chang and Chiang, 2008; Chong and Ma, 2010). Factors such as rigidity of an organization's structure (see, e.g., Walton, 2003; Sundgren, Dimenäs et al., 2005; Mahmoud-Jouini and Charue-Duboc, 2008), formalization and a strong hierarchy (see, e.g., McLean, 2005; Wang and Casimir, 2007) act as barriers to organizational creativity. In hierarchical organizations, especially, employees in positions of low power tend to adopt a more careful and reactive style, and show less creativity (Walton, 2003). Therefore, creative talent is usually considered to flourish in a loosely structured working environment with more flexibility and fewer restrictions (Pryor et al., 2010). In general, an organic type of structure is more likely to enhance creative capabilities (see, e.g., Cooper, 2005; DiLiello and Houghton, 2008; Wood et al., 2011). However, there are studies with contradictory findings (Brown et al., 2010; Bissola and Imperatori, 2011; Çokpekin and Knudsen, 2012), arguing for the importance of rules and structure for creativity. For instance, Brown et al. (2010) in their study of architects concluded that to become more creative, the studied architects used many facilitative, yet regulatory mechanisms, activities, standards, and ideals, which suggests that although the discourse emphasizes freedom, such freedom needs to be structured.

A few articles discuss the *spatial and/or physical factors* that either facilitate or hinder creativity (Haner, 2005; Sadi and Al-Dubaisi, 2008; Magadley and Birdi, 2009; Martens, 2011; Sadi and Sailer, 2011; Epstein et al., 2013). These factors comprise the fifth theme. According to the literature, in facilitating creativity, the most important aspect of designing a physical space is finding the optimal balance between space for communication and space for concentration (Haner, 2005; Sailer, 2011). Spatial settings that are noisy, too crowded, or in which an employee is not able to control the amount of interaction or privacy, can hinder creativity (Martens, 2011).

The sixth theme, which includes matters concerning the *organizational climate and culture*, is discussed extensively in the reviewed literature. Although many scholars make a clear distinction between climate and culture (Ahmed 1998; Andriopoulos, 2001; Isaksen and Lauer, 2002; Isaksen and Ekvall, 2010), the terms are often used interchangeably (McLean, 2005). Consequently, a few of the related factors, too, are referred to interchangeably, albeit with the same apparent meaning. A multitude of characteristics of organizational climate and culture have been found to drive organizational creativity. These include autonomy (see, e.g., Daymon, 2000; Mumford, 2000; Sundgren, Selart et al., 2005), challenge (see, e.g., Moultrie and Young, 2009; Isaksen and Ekvall, 2010), collaboration and free information flows (see, e.g., Mumford, 2000; Andriopoulos, 2001; Sundgren, Dimenäs et al., 2005), freedom (see, e.g., Moultrie and Young, 2009; Isaksen and Ekvall, 2010;), free exchange of ideas (see, e.g., Mumford, 2000; McLean, 2005; Sundgren, Dimenäs et al., 2005), knowledge sharing and management (see, e.g., Lapierre and Giroux, 2003; Basadur and Gelade, 2006; Schepers and Berg, 2006), encouragement of creativity (see, e.g., Martins & Terblanche, 2003; Barrett et al., 2005; Sundgren, Selart et al., 2005), and high participation rates (see, e.g., Andriopoulos, 2001; McLean, 2005; Schepers and Berg, 2006). Similarly important characteristics are support for ideas (see, e.g., McLean, 2005; Moultrie and Young, 2009; Isaksen and Ekvall, 2010), trust (see, e.g., Barrett et al., 2005; Moultrie and Young, 2009; Isaksen and Ekvall, 2010),

dynamism/liveliness (see, e.g., Moultrie and Young, 2009), diversity (see, e.g., Barrett et al. 2005; McLean 2005), playfulness/humor (see, e.g., Moultrie and Young, 2009; Isaksen and Ekvall, 2010; Lang and Lee, 2010), risk taking (see, e.g., Barrett et al., 2005; Moultrie and Young, 2009; Isaksen and Ekvall, 2010), time for ideation (see, e.g., Mumford, 2000; Barrett et al., 2005; Moultrie and Young, 2009; Isaksen and Ekvall, 2010), shared vision and open-mindedness (see, e.g., Andriopoulos and Gotsi, 2005; Tajeddini, 2009), and room for debate/conflicting views (see, e.g., McLean, 2005; Moultrie and Young, 2009; Mainemelis, 2010; Isaksen and Ekvall, 2010).

An organizational climate or culture devoid of the abovementioned attributes may constitute a barrier to organizational creativity (Martins & Terblanche, 2003; Mostafa, 2005; Mostafa and El-Masry, 2008; Sadi and Al-Dubaisi, 2008). The presence of too much or too little of an attribute such as challenge (see, e.g., Elsbach and Hargadon, 2006) may be a barrier as well. Other related barriers include a willingness to maintain the status quo, high need for conformity, unwillingness to take risks, and rigidity (Pech, 2001; Mostafa and El-Masry, 2008; Sadi and Al-Dubaisi, 2008; Unsworth and Clegg, 2010).

4.4 Macro level

The macro level refers to aspects that are external to an individual organization, such as situational or environmental factors. Only a handful of articles explicitly discuss the macro-level factors that influence organizational creativity.

The enhancing factors identified include a stable political environment that favors innovation, sufficient market potential, and an adequate distribution and communication infrastructure and legal environment (Wood et al., 2011). Furthermore, regional cultural diversity and openness to immigration (Baycan-Levent, 2010), and a national cultural environment promoting change, risk-taking, and curiosity are conducive to organizational creativity (Khandwalla and Mehta, 2004; Mostafa, 2005; Mostafa and El-Masry, 2008; Zhou et al., 2008). A few papers discuss the differences in creativity between Asian and Western cultures (Erez and Nouri, 2010; Morris and Leung, 2010; Zhou and Su, 2010), concluding that Western social norms tend to place more value on novelty, whereas Eastern norms value usefulness over novelty (Erez and Nouri, 2010; Morris and Leung, 2010). The macro-level barriers discussed explicitly concern the effects of national culture and corporate acquisition on creativity (Mostafa, 2005; Mostafa and El-Masry 2008; Hempel and Sue-Chan, 2010). Acquisitions may inhibit employee creativity in the acquired organization (Christensen, 2006), and a national culture that favors conformity and has different rules for men and women may be a barrier to organizational creativity (Mostafa, 2005; Mostafa and El-Masry, 2008 Hempel and Sue-Chan, 2010).

5 Drivers and barriers: beyond dichotomization

As discussed in the previous section, several drivers of organizational creativity can

be listed on each level of analysis from the individual to the macro, while considerably fewer barriers were recognized. The notable interest in drivers, and the more limited interest in barriers, could be a reflection of an optimistic belief that the strength of drivers can overcome any potential barriers. However, as already suggested in the paper, this alluring idea might not materialize in practice given that there is a human tendency to be more strongly influenced by negative than by positive issues (cf. Baumeister et al., 2001). Even more importantly, the dichotomizing tendency – that is, the tendency to approach the antecedents of organizational creativity respectively either as drivers or as barriers – is problematic because it fails to acknowledge that the very same factors may actually cast different, sometimes even contradictory, influences on organizational creativity. The dichotomizing tendency might also have to do with the human tendency to look for order and certainty (Tetenbaum, 1998). Therefore, looking at an antecedent's one-directional effect and ignoring that it might have an opposing effect under different circumstances is an easy and appealing option for a scholar. Presenting certain antecedents only as drivers and informing readers of how creativity is promoted through the selected drivers creates an illusion of certainty in relation to the multifaceted phenomenon of creativity (cf. Andriopoulos, 2003; Andriopoulos and Lewis, 2010). However, based on this review's analysis, scholars should adopt a more holistic perspective and look beyond dichotomies while studying organizational creativity. This paper contributes to the aforementioned aim by demonstrating that in addition to drivers and barriers, there are numerous factors that may be either drivers or barriers depending on the circumstances. In this paper, these factors are called either-or factors (see Figure 1).

Fig. 1. Examples of barriers to, drivers and, either-or factors of organizational creativity

The fact that under different circumstances the same factors might be either drivers or barriers was already explicitly reflected more than a decade ago by Amabile et al. (2002) in their discussion of the effect of time pressure on creativity under different conditions. According to Amabile et al. (2002), time pressure can act as a driver of creativity in case the employees can focus on the task and consider the task meaningful, whereas it can act as a barrier in case the task is fragmented, employees are often distracted, and the task does not feel meaningful. Some other scholars have, accordingly, discussed the contradicting or paradoxical influences of certain antecedents of organizational creativity, such as diversity and coherence (Bassett-Jones, 2005; Andriopoulos and Lewis, 2010), time and workload pressure (Baer and

Oldham, 2006; Elsbach and Hargadon, 2006), mood and affect (George and Zhou, 2002; Amabile et al., 2005), organizational culture (Martins & Terblance, 2003) and rewards (Baer et al., 2003).

Given that Amabile et al. (2002), among others, explicitly brought up the either-or nature of factors affecting organizational creativity in their widely cited study, it is, nevertheless, surprising how little attention this important aspect has received from scholars. Although there are studies that recognize the different, or even contradictory, roles of factors and discuss them accordingly (see, e.g.,; Zhou and George, 2001; George and Zhou, 2002; Baer et al., 2003; Martins & Terblanche, 2003; Bassett-Jones, 2005; Baer and Oldham, 2006; Elsbach and Hargadon, 2006; Andriopoulos and Lewis, 2010;), the predominant approach in the organizational creativity discourse is to perceive factors from a simple dichotomous perspective and focus on the driver perspective. However, it is only logical to assume that numerous factors dealt with as drivers of organizational creativity in extant studies and discussed earlier in this article could easily work as barriers (and vice versa). Accordingly, a more careful look at the drivers and the barriers recognized in this review should reveal that the very same factors might, depending on the circumstances, act either as drivers or barriers. The role of factors can vary owing to different individual, group, or organizational settings; situational or contextual aspects; or differences in the form or phase of the creative process, which draws from different psychological resources (Cropley and Cropley, 2013). As an illustrative example, other than the one provided by Amabile et al. (2002), one can think resources, for instance.

It is widely recognized that the production of creative outputs requires sufficient resources (see, e.g., Andriopoulos and Gotsi, 2000; Andriopoulos, 2001; Barrett et al., 2005). The difference between the resources currently needed and the total resources available is referred to as 'organizational slack'. In a relatively stable environment, too much organizational slack represents static inefficiency. However, slack can act as a shock absorber in a dynamic market that requires innovation and change, providing opportunities for experimentation (Bunduchi, 2009). Accordingly, too few or too many resources may constitute a barrier, whereas the right amount may work as a driver of organizational creativity. The same logic applies to several other factors such as autonomy, diversity, and conflict as illustrated in Figure 1.

Based on this paper's analysis, it can be argued that many antecedents of organizational creativity are paradoxical by nature (cf. Andriopoulos, 2003; Andriopoulos and Lewis, 2010). The concept of paradox refers to the contradiction of interrelated elements, such as opposing perspectives or contradicting demands (Lewis, 2000). In the case of antecedents of organizational creativity, it means that many antecedents might even have opposing effects on creativity depending on the circumstances. In addition to resources, mood or affect is an excellent example of such an antecedent as it has been studied quite extensively, yet conclusions concerning the relationship between mood/affect and creativity are still partial and even contradictory (Amabile et al., 2005; Klijn and Tomic, 2010). Autonomy and diversity seem to function similarly to resources in relation to organizational creativity, in that they are conducive to creativity until there is too much of them. Too much autonomy easily makes people spend time on tasks that do not align with

organizational objectives, and too much diversity makes group work difficult and fragmentary (Bassett-Jones, 2005; Andriopoulos & Lewis, 2010). Naturally, in many cases, the effect also depends on the nature or characteristics of an antecedent. As discussed in this review, certain features of organizational or national culture and certain features of legal environments promote and facilitate creativity while other features hinder it. Similarly, the nature of rewards (e.g. monetary, informative, recognition) or conflict (e.g. related to personal or job-related matters) have different effects on creativity. Although all possible contingencies cannot be covered in a review like this, they should be carefully considered when studying organizational creativity or deciding about practices aimed at facilitating creativity.

The above observations about the either-or factors affecting organizational creativity make it difficult to build an all-encompassing model or a 'global theory' (cf. Borghini, 2005) as the question remains: what is the 'right amount' or the 'right kind' in the case of individual either-or factors? The answer to such a question clearly depends on several case-specific aspects and requires further research.

However, what is said above should not let one make the wrong generalization that all factors affecting organizational creativity would be either-or factors. As Figure 1 illustrates tentatively, some factors such as supervisory support and a sense of belonging are practically always drivers and could thus be considered theoretically as 'one-directional factors'.

Although the review highlights only a handful of barriers, compared to the number of drivers, it seems logical to claim that some of them such as negative attitudes and individualistic goals might in most cases inhibit creativity. Thus, theoretically, they can be considered as one-directional factors, i.e., barriers just as illustrated in Figure 1. This is not to say that it would be impossible to encounter a situation in which an organic structure, for instance, does not act as a driver of organizational creativity. In a similar vein, there may be situations in which a homogenous group is not a barrier. Nevertheless, it seems that at least theoretically, certain factors possess some distinct characteristics that make them act as drivers or barriers in most cases. Understanding all this more thoroughly clearly requires further research focused explicitly on the topic. Based on in-depth studies, it should be possible to draw up, if not an actual 'global theory' (cf. Borghini, 2005), at least certain general rules of the thumb for many, perhaps even for the majority, of questions dealing with either-or factors and one-directional factors of organizational creativity.

6 Conclusions and limitations

This paper reports the findings of a review of antecedents of, i.e. drivers of and barriers to organizational creativity. Drivers are factors that have a positive effect on the emergence of organizational creativity, whereas barriers have a negative effect and their presence makes it difficult for the organization to be creative. The paper explicates the recognized drivers of and barriers to organizational creativity on four levels: individual, group, organization, and macro.

It seems from the review that individual and group-level creativity has attracted less interest, while organization-level studies have received the most interest. Moreover,

several studies focus on how organizational culture and climate, knowledge, leadership, and management, for example, facilitate organizational creativity. At the same time, there are very few macro-level studies focusing on situational and environmental factors, which can be considered a severe gap in the existing literature. It could thus be concluded that organization-level aspects have dominated the discourse, whereas individual, group, and macro-level aspects have aroused relatively marginal interest among scholars. This is somewhat logical as well: after all, the discourse is about organizational creativity. However, this fact should not mean that the other aspects affecting organizational creativity, including individual, group, and macro-level factors, should be ignored. Accordingly, scholars should study these aspects of organizational creativity more actively in the future.

The domination of drivers and the scarcity of barriers are apparent at each level of analysis. It is understandable that drivers of organizational creativity are more attractive as a topic of study than barriers. However, in general, equal attention should be given to both, especially because of the human tendency to give more weight to negative than positive issues (cf. Baumeister et al., 2001). Therefore, a small number of barriers may effectively inhibit creativity regardless of the effort expended toward factors that are considered to enhance creativity. Moreover, the review indicates an apparent tendency to dichotomize the factors influencing organizational creativity. In other words, it is typical for the organizational creativity discourse to discuss the antecedents of creativity exclusively from the viewpoint of drivers. In some cases, the antecedents were discussed from the perspective of being barriers, but only rarely was it recognized that the same factor may either enhance or inhibit creativity. Accordingly, in the case of these so-called either-or factors, i.e., factors working potentially either as drivers or as barriers, in future scholars should recognize both aspects and make them explicit in their analyses.

In a similar vein, there is a need for research on the mutual relationships among one-directional factors or factors that are theoretically either drivers or barriers. The general rule of the thumb would suggest that the presence of a greater number of drivers and fewer barriers in an organization is favorable for organizational creativity. However, it might be interesting to study whether it is possible, for instance, to enhance organizational creativity by increasing the number of (certain) drivers without removing (certain) barriers first. If it is, which drivers/barriers are affected, in what kinds of situations, and to what extent? These kinds of questions obviously open the door to numerous pragmatic questions regarding organizational creativity that should be addressed by further research.

This review potentially provides important managerial implications. For example, however appealing it is to encourage and promote creativity by various means, it is equally important to make sure that the potential inhibitors of organizational creativity are also dealt with. In other words, managers should pay attention not just to drivers but also to barriers in facilitating organizational creativity. Therefore, management should be very careful with any potential barriers of creativity because, for instance, a discouraging/ignorant attitude or comment from a manager may easily overcome good attempts to encourage creativity in the organization (cf. Baumeister et al., 2001). Moreover, recognizing the fact that many antecedents of organizational creativity are either-or factors is essential for managers interested in creativity. Doing so would

allow managers to acknowledge that the very same factors may enhance or inhibit creativity and help them in assessing when, how, and under which circumstances a barrier might act as a driver and vice versa. Thus, understanding the paradoxical nature and influence of many antecedents of organizational creativity (cf. Andriopoulos and Lewis, 2010) might provide managers conceptual tools, which could be helpful in enhancing organizational creativity.

This paper also has some limitations. First, although we used three important databases in the field of business and management, the initial database search or the selection of articles for further analysis might have omitted some relevant work. We have, however, attempted to avoid this by having two of the authors read all the article abstracts and collectively decide whether to select the articles for further analysis. Also, the snowballing technique was used to increase the probability of including all relevant work. Second, one obvious limitation of this paper relates to its aim, which was to review antecedents of organizational creativity, necessarily excluding other perspectives and theories regarding organizational creativity. However, to present a more balanced overview of the topic, the main theories and perspectives are briefly discussed in this paper. Third, a central limitation of this review is that it relies primarily on a keyword search. This means that studies discussing creativity but using another concept, such as innovation, research and development, organizational change, or organizational renewal were likely to have been excluded from the review. The snowball search probably compensated for this at least to some extent, but something relevant might have been omitted. This limitation is not exclusive to this review, but is a common challenge in all academic writing as it is difficult to draw exact lines between what belongs to a certain academic discourse and what does not. Therefore, it is reasonable to assume that this paper provides a comprehensive and topical review of antecedents of organizational creativity and that any research excluded or omitted from the review would not have changed the main arguments and conclusions.

Drivers and barriers are clearly an important topic in the field of organizational creativity. However, even though new studies are emerging at a higher rate than ever before, on the basis of this review, it is fair to say that only the surface has been scratched – perhaps excluding organization-level drivers, which have been studied extensively. We hope that this review will provide scholars with new ideas and insights into how to approach the antecedents of organizational creativity in future studies.

7 Endnotes

1. In this paper, the concept of discourse refers to structured collections of related texts that denote certain ways to address a particular phenomenon (cf. Hardy and Phillips, 2004, p. 299).
2. The databases were: ABI/Inform (ProQuest) Global, Business Source Complete (EBSCO), and Emerald Journals (Emerald).
3. The search phrase stipulates that both the word ‘organization’ or its British version ‘organisation’ and the word ‘creativity’ appear in the abstract or the

citation/keyword field, and/or in the title of the article. In addition, the '*' symbol was used for multiple character wildcard searches, so that it looks for 0 or more characters. This meant that the search included words such as organizations, organization, and organizational. (see Blomberg, 2014.)

4. While Woodman et al. (1993) use the term 'contextual influences', in this paper we prefer the term 'macro', as we discuss the different levels of organizational creativity.

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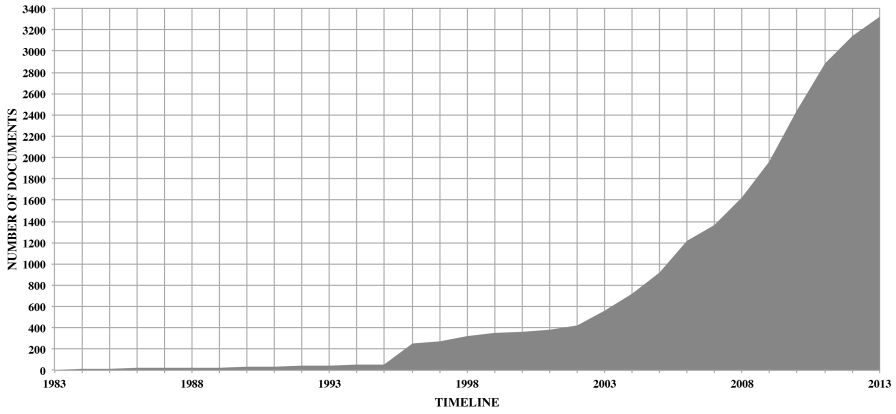
Appendix 1 Growth in number of documents mentioning organizational creativity



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Environmentally sustainable innovations in offshore shipping: A comparative case study

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Abstract. Two Norwegian offshore shipping firms facing the challenge of developing more environmentally sustainable services choose divergent strategies. One focuses on managerial innovation and develops a new business model equally dividing fuel-savings achieved through operational optimization between customers and the Norwegian Rainforest Foundation, thus operating climate neutrally. The other firm develops a technology-driven strategy and develops LNG-propulsion for part of its fleet. Following the firms through the innovation processes, the study finds that implementing environmentally sustainable innovations requires managerial capability to provide a holistic and integrative perspective on organizational innovation processes which align technical and managerial actions and activities. The findings indicate that a business model can be used as a boundary-spanning tool that goes beyond the ambidextrous challenges of balancing and integrating exploration and exploitation and provides a complementary view on organizational innovation processes. The comparative case study looks inside the "black box" of sustainable innovation and offers theoretical and practical insights to academics and students. The study also contributes guiding principles for practitioners and policymakers.

Keywords. Innovation, comparative case study, environmental sustainability, offshore shipping, technological and managerial capability, business model.

1 Introduction

Norway has one of the largest and most comprehensive maritime sectors in global terms. Its offshore fleet is the second largest in the world[1], and the industry is characterized by high competence, innovation, and advanced technology. Norwegian maritime clusters comprising leading shipping companies, shipbuilding yards, equipment manufacturers, designers, service providers, universities, research and development centres, and regulatory bodies are among the world's leading suppliers of innovative and environmentally friendly solutions (Benito, Berger, de la Forest, & Shum, 2003; NSA, 2016).

In the global context, sea transport is a cost-effective, reliable, and comparatively environmentally friendly mode of transport, and some 90% of goods are transported by sea. According to the International Maritime Organization (IMO), maritime shipping

[1] The Norwegian maritime industry accounted for approximately 5.5% of Norway's GDP in 2012, and the maritime industry is the country's second largest export industry after the oil and gas sector.

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accounts for 2.2% of global CO_2 emissions (IMO, 2014), and while the general debate continues on just to what extent industrial activities impact the environment and what needs to be done about it (Mendonca & Oppenheim, 2007), the maritime industry, amongst others, has b*een called to action by the Brundtland report's call for an increased focus on sustainability[2] (UN, 1987). Accordingly, and in line with many other industries, more sustainable maritime shipping has during the past 10 to 15 years increasingly become a political, public, and business concern. The issue has also been on top of the agenda for national and international organizations representing ship owners, such as the Norwegian Shipowners' Association (NSA) (Henriksen, 2014) and the International Maritime Organization (IMO, 2013).

This development has also stimulated a growing body of literature on *corporate social responsibility* (CSR) (Bocken, Short, Rana, & Evans, 2014; Porter & Kramer, 2006) and *corporate greening* (Cohen & Winn, 2007), but despite this growing scholarly interest, management research still lacks a varied empirical examination of sustainable business practices and the potential for entrepreneurial rents arising from environmentally friendly innovations. And this is in spite of Porter and Kramer's (2006) reminder 10 years ago with reference to CSR that "companies are called on to address hundreds of social issues, but only a few represent opportunities to make a real difference to society or to confer a competitive advantage" (p. 92).

This study contributes to meeting this challenge by analysing how two *environmentally conscious* (Huang & Kung, 2011; Lynes & Dredge, 2006) Norwegian firms engaged in offshore maritime operations in the oil and gas sector chose different innovation paths in their search for more sustainable operations. The study responds to specific calls from scholars from both the natural and the social sciences to gain more knowledge about firm-based technical and managerial actions and activities involved in the process of going green in the maritime industry (Dalsøren et al., 2009; Gjosaeter & Kyvik, 2017; Helfre & Boot Couto, 2013; Mansouri, Lee, & Aluko, 2015). Based on recent theoretical perspectives on innovation (Giannopolou, Ystrom, & Ollila, 2011), this study specifically has an objective to open up the "black box" (Brown & Duguid, 2000; Sydow, Schreyogg, & Koch, 2009) of innovation and explore two real-life innovation contexts to determine the role played by technical and managerial resources, competencies, and capabilities in innovation processes aimed at more sustainable maritime operations. With its comparative analysis, the study will first and foremost contribute to the body of knowledge by revealing how two Norwegian offshore shipping firms facing the same environmental challenge chose very different strategies to reach the goal of more sustainable shipping services.

The next section describes the study's conceptual foundation. Then the design of the study and the methodological approach are outlined, followed by an elaboration of the cases forming the empirical basis of the research. Subsequently, the findings are explored, before the study concludes with a discussion of the implications, outlining the contributions of this research and indicating avenues for future study.

[2] The Brundtland report defines sustainability as "the ability to meet the needs of the present, without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development (WCED), 1987).

2 Conceptual foundation

Conceptually the study refers to a combination of several bodies of literature seen as offering explanatory theory relevant for the two empirical cases. However, notably, each body of literature and its disciplinary origin overlap, jointly contribute knowledge, and add theoretical perspectives on the complexity of the firms' strategic choices and the actions and activities forming part of the innovation processes on the path to improved sustainability.

With reference to factors pertaining to *individual- and firm-level entrepreneurial conditioning*, since the two firms are relatively small and specialized in one particular industrial segment, the resource- (Barney, 1996) and capability-based views of the firm (Grant, 1996; Teece, Pisano, & Shuen, 1997) are seen as central in explaining the firms' entrepreneurial urge, active searches for opportunity (Baron & Ensley, 2006), and approaches to strategic choices and strategic fit along their chosen path. Secondly, the firms' common Norwegian cultural setting, maritime business origin, and shared history as entrepreneurial and family-based firms are also seen as explanatory factors, on both the individual and the collective firm levels (Kotey & Meredith, 1997), and as helpful to understand the firms' individual strategic developments. These factors are also seen to explain the motivations behind the two firms' *green* strategies. In addition, they are in line with more recent findings showing that sustainable entrepreneurship has the potential to slow the degradation of and even gradually improve the earth's ecosystems (Cohen & Winn, 2007), and that the maritime industry can offer important contributions (Henriksen, 2014; Mansouri et al., 2015).

The firms form part of a strong maritime cluster on the southwest coast of Norway (Benito et al., 2003; Reve, 2009), and the positive effects on innovation performance (Zeng, Xie, & Tam, 2010) of *cluster-collaboration, networking, and knowledge-sharing* within a geographic area (Krugman, 1991; Marshall, 1920; Pouder & St. John, 1996) or within a field of competence (Decarolis & Deeds, 1999; Fontes, 2003), and particularly among resource-scarce smaller enterprises (Brunswicker & Vanhaverbeke, 2015), are well recognized both in practice and in the literature. While it is also recognized that the term innovation itself has many different meanings, actions and activities depending on the industry and context "which one must understand and study separately" (Jenssen & Nybakk, 2009 p. 460), scholars nevertheless seem to agree on the positive relationship between knowledge-sharing, absorptive capacity, and how informal industry networks, in line with prior research (Kaish & Gilad, 1991), are "found to be directly related to entrepreneurs' alertness to new opportunities" (Ozgen & Baron, 2007, p. 186).

Firms are social agents (Pitelis, 2009) and form part of the development of society, thus creating a *societal sustainability impetus*. The increasing focus on CSR (Porter & Kramer, 2006), global warming (Mendonca & Oppenheim, 2007) and emissions from ships (IMO, 2014; Skjølsvik, Andersen, Corbett, & Skjelvik, 2000) have undoubtedly led to social pressure on firms' owners and employees to contribute to a more sustainable industry. This trend is clearly reflected in maritime organizations' strategies and propaganda (Henriksen, 2014; IMO, 2014; NSA, 2016), but it is also seen in the increase of attention in the literature to establishing how much the world fleet pollutes through emissions (Dalsøren et al., 2009), and also to other effects of maritime

operations, such as waste (Butt, 2007; Encheva, 2015), emissions while in port (Scott, Gössling, Hall, & Peeters, 2016), and negative externalities of cruise tourism (EU Commission, 2009).

Combined, these developments have greatly influenced and formed the background for developing the *going green innovation process* and the empirical setting of the case studies. In particular, the recent work with a focus on climate-neutral offshore shipping operations (Gjosaeter & Kyvik, 2017) provides perspectives on the balance between operational innovations, customer orientation, and development of a business model supporting the sustainable development, and indicates a crucial link between innovation, entrepreneurial drive, and the user of or market for the innovation. Huang and Kung (2011) study the "greening" of management focus based on a quantitative analysis of Taiwanese firms' environmental consciousness, finding positive relationships between environmental consciousness, green intellectual capital, and competitive advantage, and concluding firmly that "the world is entering a green era" (Huang & Kung, 2011, p. 1420). In a more discourse-based study of the motivations for the airline industry to "go green", the sustainable development debate is presented as a quest for greater integration of the economy and the environment, but with the question of using market-based instruments of environmental policy or the setting of environmental standards by direct legal regulation (Lynes & Dredge, 2006). Their findings "suggest that environmental management practices should be aimed at reducing costs, delaying or avoiding regulatory action, reinforcing a positive image (being a good corporate citizen) and should respond to pressure from corporate customers and client stakeholders" (p. 135). However, the scholars go on to point out that the social sciences do have role to play in developing scientific indicators and behavioural patterns to benchmark what are socially and politically legitimate management decisions. This may also be interpreted to coincide with a call for an increased cross-disciplinary research orientation in response to the need for more relevant research on sustainability within the field of management and organizational science (Skoglund, 2015).

This leads to a final contributing construct of the conceptual framework, which is the search for a *sustainable business model* — a model able to balance the various social- and market-related requirements. In essence, a business model embodies nothing less than the organizational and financial architecture of a business (Chesbrough & Rosenbloom, 2002), and thus articulates the conceptual logic while also providing structure and eventually data (revenue and costs) demonstrating how a business creates and delivers value to customers. Since the relaunching (Trott & Hartmann, 2009) of the business model concept (Chesbrough, 2003), much has been published on business models and increasingly also with a focus on *sustainability* (Sarkis, De Bruin, & Zhu, 2013). With reference to relatively recent literature (Charter, Gray, Clark, & Woolman, 2008; Schaltegger & Wagner, 2011), Boons and Ludeke-Freund (2013) point out that how firms succeed in bringing an invention to the market is still relatively unexplored in the field of sustainable innovation, and they elaborate how business models and sustainable innovations interrelate to form separate, but overlapping, research streams — one with a technological focus, one organizational, and a third centred on social innovation. Their conclusion is that "sustainable business models enable social entrepreneurs to create social value and maximize social profit; of significance is the

business model's ability to act as market device that helps in creating and further developing markets for innovations with a social purpose" (p. 16). *How* this process is managed is however not elaborated by the authors.

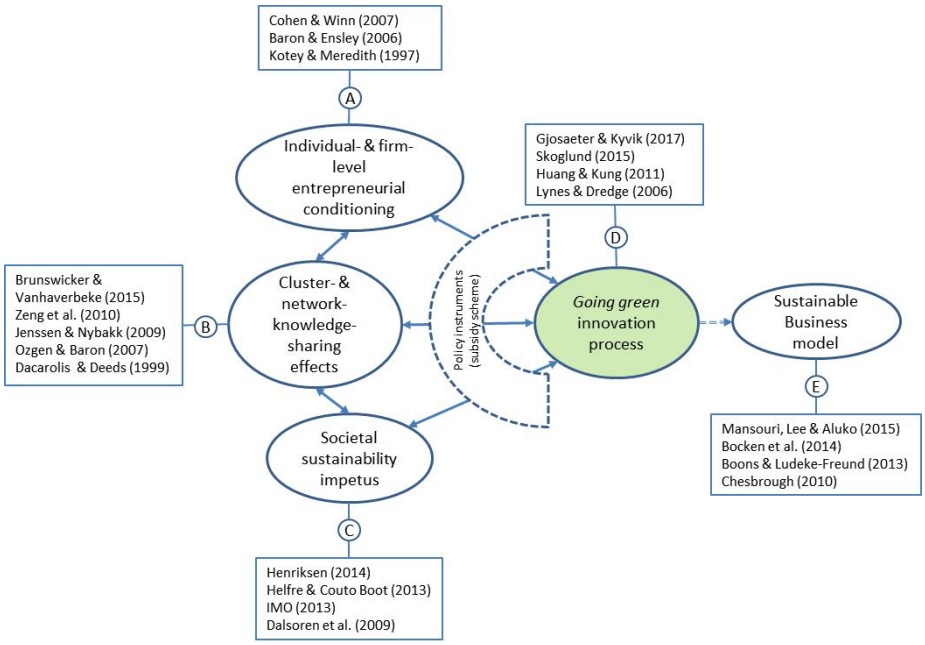

Fig. 1 Conceptual framework

The conceptual framework for this study is illustrated and summarized in Figure 1. It should be noted that the double arrows are meant to indicate interrelationships and a partial overlap between the constructs; however no causal effects or effects between the constructs over time are implied. Using a combined activity- (Johnson, Melin, & Whittington, 2003) and resource-based view of the firm, the study elaborates empirically the role of resources, competencies, and capability in organizational innovation processes within the two case companies aiming to provide a more environmentally sustainable offshore shipping service. These combined perspectives were chosen because of their specific focus on the study of work as a flow of activities (needing resources and capability) while addressing the detailed processes and practices that constitute the day-to-day activities of organisational life and which relate to strategic outcome (Johnson, Melin, & Whittington, 2003). The present study, on the basis of its rich empirical context, contributes valuable additional insights to the understanding of organizational innovation processes and the balance between technology, human competence, and commercialization. Partly based on the literature review and partly based on the empirical context, this study poses the following research questions:

1. How does the firm context (company culture, history) influence the emergence of sustainability-innovation strategy and subsequently the flow of activities and actions forming part of the innovation process?
2. Forming part of the same sector and located in the same geographic area, why

did the firms choose different innovation strategies?

3. Within each firm and in its strategic context, which factors are main drivers and enablers for the innovation process?

In line with the conclusion that "when a well-run business applies its vast resources, expertise, and management talent to problems that it understands and in which it has a stake, it can have a greater impact on social good than any other institution or philanthropic organization" (Porter & Kramer, 2006, p. 92), in addition to addressing the research questions, this study also offers perspectives on how the art and science of management, as an important part of the social sciences, may contribute with examples of practical and innovative solutions on the path to more sustainable offshore shipping.

3 Research design and methodology

A comparative and exploratory case study design was chosen because a lack of in-depth knowledge about the role of resources and competencies in innovating environmentally sustainable and profitable offshore shipping services made it impossible to advance well-grounded a priori hypotheses (George & Bennet, 2005). Further, a qualitative approach (Denzin & Lincoln, 2000; Eisenhardt, 1989; Ghauri & Grønhaug, 2010) was used to gain a more thorough understanding of the organizational innovation processes and the role played by resources and professional competencies within the two case companies than is offered by a quantitative methodology (Graebner, Martin, & Roundy, 2012), which is often conducted as a survey investigating relations between dependent and independent variables established in advance (Edwards & Bagozzi, 2000; Revang & Olaisen, 2014). A cases-in-the-case design (Yin, 2014) with several observational units within each case company was established with the objective of providing primary data in a way that is rather rare within strategic innovation research. The research ambition was thus not only to approach, but also to look inside the black box (Brown & Duguid, 2000) of activities and actions involved in the various phases of the innovation processes and thus provide a richer understanding.

With the firm as the research context, two comparable maritime firms from the same industry sector were selected, and within in each case company four vessels were chosen for data collection. The four vessels selected as observational units within case company A were chosen on the basis of the results of their environmental efforts at the time the study commenced (2009), and in case company B four out of five available ships were chosen on the basis of their propulsion system (LNG[3]). An overview of the research design developed for the study is shown in Figure 2, and it should be noted that the unit of analysis is the *cases of innovation processes* within each of the firms. For both cases, primary and secondary data were collected on various organizational levels both onshore and offshore and in continued dialogues and coordination with the firm's top and middle management.

[3] LNG = Liquefied Natural Gas

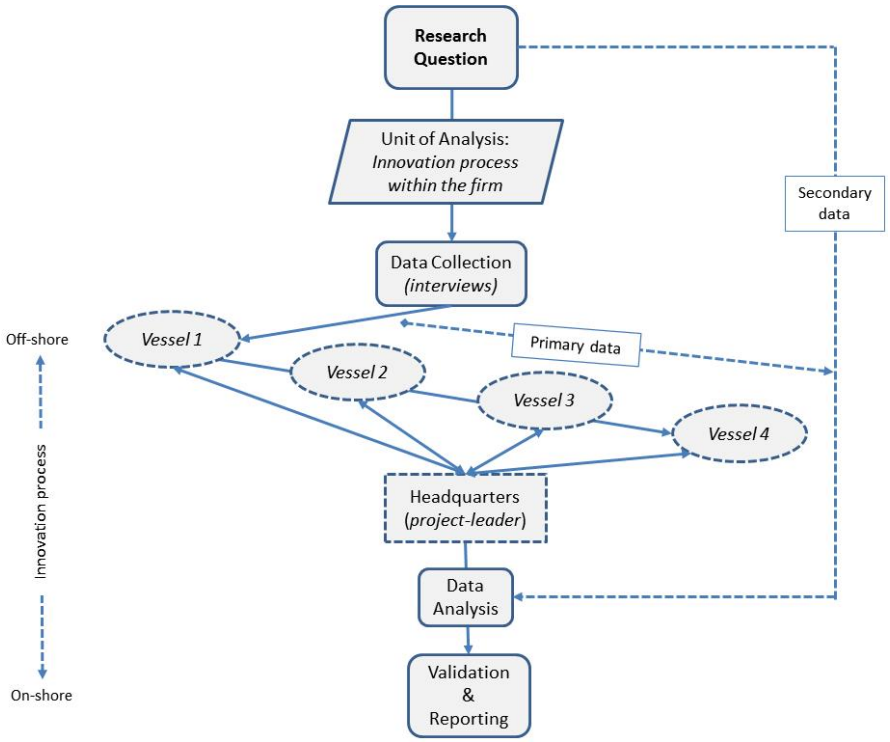

Fig. 2. Research design (adapted based on Gjosaeter & Kyvik, 2017)

An initial meeting with the project leader in company A, who reported directly to the managing director, was arranged to obtain an overview of activities, establish a level of confidence, and secure access to the four vessels. Similarly, an up-front coordination meeting was arranged with the engineering director who was in charge of the project in company B. Based on data from these first meetings and information obtained from secondary data sources, a semi-structured interview guide was developed. Thereafter, interviews were performed with onshore personnel as well as managers and crews on board the vessels, and the data collected was amplified and cross-referenced by secondary data from company records, press coverage, and press releases. The appointments to conduct the interviews on board the selected vessels were arranged in cooperation with the project leader in each firm and scheduled to take place when the vessels were in port. Since some of the vessels did not often approach nearby ports, the first interview on board a vessel was conducted in early 2011 and the last one late in 2012.

The interviews were conducted in an open and conversational manner, allowing for topics to emerge during the sessions. Some of the interviews were conducted in the captain's cabin, some on the bridge, and others in the vessel lounges, as was most convenient for a ship in full operation and preparing for the next assignment. The interviews in the captain's cabin were with the captain himself as the only interviewee, while the interviews on the bridge usually were with the whole management team (depending on operational requirements at the time, this team comprised some or all of

the captain, the chief mate, the chief engineer, and the steward). The interviews lasted for one to three hours, followed by guided tours around the vessels that also included brief conversations with other crew members. After the interviews with the management and crews on board the four chosen vessels in each firm, a final interview lasting for a whole day was conducted with onshore management to validate the findings and their significance thus far in the data collection process.

The data collection through interviews took place over a period of almost two years, during which the activities and actions forming part of the innovation processes in the two firms were gradually operationalized at all organizational levels both on and off shore. This is seen to strengthen the validity of the findings, as they emerge as part of a real-life evolutionary process where the vision might be questioned by the practitioners in the beginning before gradually being accepted and adopted through on-the-job dialogues and activities. At the end of the data collection process, the nine interviews with firm A and the ten interviews with firm B, all digitally recorded, were transcribed and subsequently interpreted separately and then jointly by the two interviewers. It should be noted that the interview-based data collection was somewhat constrained by the fact that the interviews were performed while the ships were in full operation, thus time with and access to the offshore CEOs (the captains) were limited. Due to circumstances onboard two ships, for instance, the captain was not available. However, it is still perceived that the data collection resulted in data saturation, as new themes did not occur during the interview sessions towards the end of the data collection process. Based on a comparison of notes between the two interviewers and an open dialogue when perceptions diverged, it was concluded that the empirical data fully represents the strategic and operational logic of the two firms. For further validation, the interview data was triangulated with secondary data covering the entire data collection period and until the end of 2014. In addition, the interpretation of the findings has been supported and amplified by follow-up conversations with the project leaders of the two firms.

4 Empirical context and case studies

The contextual foundation of the comparative case study is summarized in Table 1, indicating both similarities and differences between the two case companies (NSA, 2011). Notably, both firms are engaged in the Norwegian petro/maritime shipping sector, have vessels of a similar class, and offer comparable, but not identical, services. With a historic perspective, company A has grown more rapidly from being a start-up in the 1960s, after altering its strategic focus from deep-sea shipping to the offshore shipping segment. With reference to Table 1, it is also in general terms deemed reasonable to classify company A as more transport and support oriented and company B as relatively more technically advanced and specialized in its operation.

Below follows a presentation of the context of the two innovation-process case studies following Yin's (2014) cases-in-the-case research design.

Table 1. Comparative firm characteristics (2016)

	Case company A	Case company B
Number of vessels	50	25
Type of vessels	Construction service; anchor-handling tug-supply; platform-supply	Platform-supply; subsea; seismic
Type of fuel (M/E[1])	MDO[2]	MDO 79 %/LNG[3] 21 %
Main market	World wide	World wide
Number of employees (approximate)	1800	900
Ownership	Family-controlled publicly listed company	Family-controlled publicly listed company
History	Liner/deep-sea shipping	Fishing ships

Notes: 1 = Main engine
2 = Marine diesel oil
3 = Liquified natural gas

4.1 Case A: Green operations campaign

The innovation process within case company A began as a campaign to reduce the consumption of fuel by offshore service vessels. The campaign, which started in the fourth quarter of 2009, was motivated by a Norwegian governmental incentive scheme allowing for tax deductions for shipping companies' efforts to reduce environmentally damaging emissions. The initial aspiration of the firm was to reduce the fleet's total diesel fuel consumption by some percentage, initially without an exact target. After a while, however, the target was specified as a 10–20% reduction, or up to 20,000 tons (approximately 23,000,000 litres) of diesel a year. The reduction in fuel consumption was to be achieved by carrying out fuel-saving *green operations* on board the vessels. A green operation was defined as a saving of 500 litres (or 0.5 m^3) of diesel fuel in specific operational manoeuvres during a day. By carrying out various forms of fuel-saving operations the company manifested care for the environment while at the same time building a competitive advantage by operating in a cost-effective manner. The company also strategically branded itself as a *green* shipping company in all external (marketing and profiling) communications.

In 2011 the company extended the campaign by introducing a new environmental concept for the fleet. The concept was named Climate Neutral Operations (CNO), and the objective was to compensate for the exhaust emissions from the fleet of vessels by introducing the opportunity for customers to contract *climate-neutral* ships. This was done by splitting the diesel cost savings equally between the customer contracting the vessel and a contribution to the Norwegian Rainforest Foundation (donor to the United Nations Rainforest Foundation).

The environmental efforts of the company have been recognized at the national as well as the international level. The Norwegian Minister for Environment and International Development expressed in an announcement in 2013 that he was impressed by the

company's environmental work, emphasizing the importance of taking the initiative to implement such an important and forward-thinking environmental model as the CNO concept, which is ahead of both the current market and regulatory requirements. In 2014 the company was also listed on the exclusive CDP[4] Climate Performance Leadership Index for 2014 with the highest score. The Climate Performance Leadership Index is based on an assessment of the environmental efforts of major companies worldwide, a rating done both to highlight the environmental performances of companies and to provide investors with the opportunity to assess the environmental profile they choose to invest in. Company A was one of only three Norwegian companies included on the list, and the only shipping company.

The firm was established in the 1960s as a start-up venture and is today a publicly listed company. With reference to Table 1, the firm had at the time of the study approximately 1800 employees (including onshore and offshore personnel), and a total fleet of 50 vessels. A project leader reporting directly to the CEO and working in close collaboration with the top management team and operations staff was hired from outside the company to run the fuel-saving campaign.

During 2010, according to company records fuel savings of about 10% were achieved compared to before the campaign was launched. Since then fuel savings have gradually increased year by year up to and including 2013, when according to company records the savings reached 25–30%. The corresponding reductions in environmental emissions include among others nitrogen and CO_2. The yearly reduction in diesel costs is estimated at NOK 25–30 million, or USD 4–5 million. In addition, maintenance costs have been reduced because less use of the engines of the four vessels results in less wear and tear.

It should be noted that these achievements have been realized without any additional capital investment and thus represent managerial innovation through more efficient use of existing technical equipment and optimization of operational routines carried out by motivated and well-trained management and crews both on board the vessels and on shore.

4.2 Case B: Development of innovative LNG technology

Case company B was pioneering innovation processes aimed at developing LNG-fuelled main engines for offshore service vessels. The initial trigger for the innovations was the sharp rise in oil prices in 1999. One of the consequences of this rise was a corresponding increase in diesel fuel costs, leading to serious concern about how to reduce the cost of fuel. Company B decided to investigate if LNG might be used as marine fuel for its ships, since this type of fuel was cheaper than diesel fuel and had the greatest potential for reduction of emissions to the air, particularly of CO_2. LNG consists mainly of methane (CH_4), and has previously been used in steam boilers, gas turbines, and various types of engines. Furthermore, a ferry using LNG as fuel instead of diesel had recently been put into operation on the west coast of Norway, drawing attention to the possibility that LNG might also be used for fuelling offshore service

[4] CDP = Carbon Disclosure Project, https://www.cdp.net/en-US/Pages/About-Us.aspx, accessed 18.05.2016.

vessels. In collaboration with Innovation Norway[5], a local shipyard and technical consulting companies within the adjacent maritime cluster, the company in 1999 started the pioneering innovation processes aimed at developing the first offshore supply vessel in the world fuelled by LNG. In 2003 the first vessel was delivered ready for operation in the North Sea. Partly subsidized by Norwegian governmental grants, company B invested in four additional LNG-propelled vessels during the next 10 years and now has a total of five vessels operating on LNG instead of diesel fuel.

With reference to Table 1, the history of the firm is similar to that of company A. It was established in the 1960s by two brothers, but began as a fishing company. During the 1970s the company entered the offshore market, and by the end of the 1970s the company operated a fleet of three vessels servicing the offshore petroleum industry. Today the fleet totals 25 vessels made up of platform supply vessels, subsea vessels, and seismic vessels. The total number of employees is about 900 on and off shore. The company is owned by the founder's family. A key characteristic of the company is that it has always been in the forefront regarding environmental sustainability. To our knowledge no other offshore shipping company in the world has been prepared to support technological innovation processes by way of capital investments aimed at realizing environmentally sustainable shipping to the same extent as company B.

The environmental efforts of the company have according to company records resulted in significant reductions in releases of detrimental emissions from the vessels operating on LNG instead of diesel fuel, gradually increasing from 2003 when the first LNG-operated vessel was put into operation up till 2016 with 5 LNG-fuelled vessels in operation, representing a total reduction of 20–25% compared to using diesel fuel. The use of LNG as fuel instead of diesel has resulted in about 80% less nitrogen and about 20% less CO_2 released into the atmosphere. The consequent reduction in fuel costs for the company's fleet of vessels is reportedly about NOK 10–12 million, or about USD 1.5 million, on a yearly basis.

It is emphasized that the innovation processes of company B are very distinct from those of company A in that they are technologically driven and include a significant capital investment in new technology, reflecting a long-term technical commitment to LNG as fuel.

Below are presented the comparative findings of how the two companies implemented their environmentally friendly innovation strategies.

[5] Innovation Norway is the Norwegian government's institution for innovation and development of Norwegian enterprises and industry.

5 Operationalization of the innovation strategies: Empirical findings and analysis

5.1 Case A: Green operation campaign – a managerial invention

The campaign launched by case company A in 2009 to operate the fleet of offshore service vessels in a more environmentally sustainable manner was primarily motivated by governmental grants allowing for tax deductions for initiatives to reduce detrimental emissions to sea and air by maritime shipping. The stated objective to realize environmentally sustainable shipping by carrying out fuel-saving operations on board the vessels resonated well with prevailing societal trends and values. It quickly became a salient issue within the offshore shipping industry, recognized on both the national and international levels. The creation and promotion of a strategic idea for which the time was right was therefore a vital precondition for making the *green operations* campaign an environmental as well as a financial success, as confirmed by one of the interviewees: "The campaign would probably not have become so successful if it had been launched at an earlier stage."

The strategic objective was supported by the development of a goal-oriented and innovative business model that supported acting out fuel-saving green operations. The business model was based on the idea that 50% of the cost savings obtained through carrying out fuel-saving operations were to the benefit of the customer contracting a vessel, and the other 50% of the savings were to be assigned to the Norwegian Rainforest Foundation. In collaboration with its customers the company was to compensate for its environmentally damaging emissions by investing in and supporting projects that were certified for CO_2 cuts in accordance with the United Nations climate quotas. Through this contractual arrangement the customers were made financial benefactors of the green operations campaign. At the same time, the strategic objective to operate the vessels in an environmentally sustainable way was linked to the preservation of rainforests. In addition, the establishment of the CNO concept in 2011 provided for making the customers even more involved in the company's environmental work. The CNO concept was designed to enable climate-neutral shipping to be a commercially profitable measure for the company as well as its customers.

A further key precondition for implementing the strategic idea was concretizing *how* environmentally sustainable offshore shipping services might be realized on board the vessels. To this end, the project leader of the campaign sent an invitation to the vessel captains inviting them to propose ideas for how green operations might be transformed into operative reality. In response to the invitation, about 150 proposals were received. The collected proposals were consolidated into seven main categories of fuel-saving operations, as a cooperative effort between onshore and offshore management. The consequent repertoire of fuel-saving green operations comprised anchoring, drift, reducing transit speed, green dynamic positioning, stopping the main engine, optimizing trim, and reducing electrical consumption. The menu bridged the strategic objective and concrete actions and activities on board the vessels to realize the idea, thus constituting the "aim and fire" of concrete operational actions and activities, as confirmed by a captain: "We also did a lot of this before, but now it was systemized..…

The concretizing processes have bridged the strategic idea and how to operate in an environmentally sustainable way on board the ships."

Implementing environmentally sustainable and profitable offshore shipping presupposed that the captain on board a vessel, in close cooperation with management and crew, had to have his "hands on" all operational activities, conducting green fuel-saving operations whenever an opportunity for suspending the normal way of operating the vessel arose. In addition, the customer contracting a vessel had to agree to initiating a fuel-saving operation. In the beginning the customers were, however, hesitant supporters of the campaign. Promotion of the idea to customers to make them stakeholders in the campaign was, therefore, an important activity, initially focusing mainly on the cost savings to be achieved. Gradually, however, the customers realized that the green operations initiative constituted a win-win project, and little by little became supporters of the campaign. Thus, acting out fuel-saving green operations presupposed close contact with the customers on a daily basis to decide if any fuel-saving operations should be carried out, while at the same time taking into consideration the operational risks involved in carrying out one or more operations. As described by a chief mate: "We discuss with the customer whenever there is an opportunity. There is a continuous dialogue regarding what is going to happen during the day, particularly at the morning meeting, and then we decide if we for example can shut down one engine or more." Thus, executing fuel-saving operations demanded campaigning for the strategic idea as an environmental as well as a financial issue, despite the fact that half of the cost savings obtained through carrying out green operations was of direct financial benefit to the customer.

Further, maintaining momentum in acting out environmentally sustainable and profitable offshore shipping was facilitated by organizing the green operations campaign as an internal competition among vessels. The green fuel-saving operations carried out were recorded on a daily basis and reported to the project leader. The project leader reported accumulated green operations achieved by each vessel on a quarterly basis. The number one vessel for a quarter was awarded a small amount for its welfare fund. In addition, the crews on board the three best vessels were awarded T-shirts marked with a *green operations* symbol. Furthermore, a vessel that managed to achieve the target of 200 fuel-saving operations during a year received a green flag to be hung from the mast showing that her crew have a strong environmental focus in their day-to-day work. The internal competition encouraged managers and crews to continually look for new ways of operating the vessels in environmentally sustainable ways, as verified by a chief engineer: "Carrying out fuel-saving operations has become an internal competition where one does not want to appear too low on the quarterly reports stating 'green operations' carried out."

Achieving environmentally sustainable and profitable offshore shipping called for leadership of the innovation processes, more or less on a day-to-day basis. First and foremost, realizing the strategic objective demanded leadership in shaping alignment around the twofold objective of environmental sustainability and profitability. In this respect, caring for the external environment was an idea that resonated with prevailing societal trends and values. However, acting out environmentally sustainable and profitable operation of the vessels also called for managerial capabilities to infuse the strategic idea into actual strategy, including the support of a dynamic business model,

presupposing continuous enactment of the organizational innovation processes. This included top management's detached coping acts (Sandberg & Tsoukas, 2011) implying abstract reflection on the firm's strategy, as well as the crews on board the vessels carrying out green operations as practical coping acts as the campaign was operationalized. Realizing environmentally sustainable and profitable offshore shipping presupposed an evolving and dynamic organizational activity system supported by an appropriate business model, and the management team of company A seem to have managed to keep a pragmatic balance between the left brain (rationality) and the right brain (creativity) in their business model development (Osterwalder & Pigneur, 2010) by encouraging participation and creating ownership of the objectives of the campaign. They also kept close contact with customers throughout the campaign.

5.2 Case B: Development of innovative LNG technology – a technological thrust

A key antecedent for company B's technological innovation processes aimed at realizing LNG-fuelled offshore service vessels was its history as an entrepreneurial "down to the trawl" fishing operation dependent on the natural resources provided by the sea, demanding that the company care for the environment in addition to doing business. A statement by the late founder of the company referred to by one of the interviewees confirms that business is "in any case not only financial results". This statement indicates that the founder wanted the company to attain more than pure business goals. Another interviewee expressed that the founder wanted to be a pioneer in realizing environmentally sustainable maritime shipping: "He wanted to bring the shipping industry on a more environment-friendly track. Therefore, we take responsibility for developing and using technology in a new way that saves the earth from unnecessary environmentally detrimental emissions."

The spirit of the founding brother, who died in 2002, has lived on, and the company has been prepared to financially support environmentally friendly technological development campaigned for by the chief technical officer, who worked closely with the founder during the early years of the innovation process. The continued technological drive was above all welcomed by the onshore engineering staff, considering the LNG project as an interesting and challenging technological endeavour, and LNG as the "the bridging fuel" between diesel and future, more environmentally friendly forms of energy. An interviewee characterized the LNG venture as the company's "moon landing project"; a journey he wanted to take part in. The strategic ambition to operate offshore service vessels on LNG constituted a technological challenge that generated extra energy among the engineering staff. Even further, the company's environmental efforts created organizational pride and made it an attractive employer, as stated by one of the interviewees: "Our innovative efforts take the industry a step forward every time." The environmental efforts of the company also resonated with stated organizational values: responsibility, good seamanship, integrity, passion, innovation, sobriety, and commitment. In addition, environmentally sustainable shipping contained an ethical aspect related to caring for the external environment as a moral foundation of the technological innovation drive.

However, innovation of LNG-fuelled vessels also rested on the technical resources within the adjacent maritime cluster comprising among others companies within the consulting industry and the maritime motor industry, as well as competitors within the

offshore shipping industry. Cluster networking facilitated knowledge sharing, complementing the case company's in-house technological knowledge base. The company became a pioneer and first-mover within the offshore shipping industry to operate LNG-fuelled offshore service vessels, which also made it a pathfinder in the development of rules and regulations for LNG-operated offshore service vessels, in collaboration with the Norwegian Maritime Authority. The involvement in this work contributed even further to creating momentum in the technological innovation processes.

An additional promoter of the technical innovation processes aimed at saving fuel was the progressively competitive market situation within the offshore shipping industry. Since other international offshore shipping companies to a larger extent than Norwegian companies benefited from employing offshore crews that were less costly than Norwegian seafarers, company B considered LNG fuel as a cost-saving opportunity. The customers, on the other hand, were primarily interested in getting an offshore service job done as cost-effectively as possible, but in the end caring less about environmentally damaging emissions. Thus, even though the company branded itself as an outstanding environmentally responsible company, the corporate image thus gained did not enable it to earn a market premium for its more environmentally friendly offshore shipping services. Company B reaped the benefits of its LNG investments through fuel savings, but did not succeed in developing a business model to complement its sustainability strategy.

5.3 Analysis of empirical findings

Company A successfully operationalized its green operations strategy empowered by prevailing societal trends and internal values regarding environmental sustainability. Strategic implementation was supported by the construction of an innovative overarching business model which allowed for alignment of financial and environmental objectives while creating a win-win solution for both the firm and its customers.

Concretizing the implementation of the strategy by determining shipboard actions that would enable the objective to be reached while at the same time winning the minds and hearts of managers (offshore and onshore), constituted key elements in transforming the strategic idea into an operative reality. In addition, designing a results-oriented and accountable system for recording fuel-saving operations launched a competitive spirit among the vessels to carry out the most green operations and helped maintain momentum in the innovation processes.

Company B's approach to realizing environmentally sustainable shipping rested on its technological LNG-based innovation drive. The innovative development of LNG-fuelled propulsion constituted an interesting technological challenge, particularly among the onshore engineering staff, who perceived LNG as a bridging fuel between diesel fuel and future energy solutions en route to even more sustainable forms of energy for marine vessels. The in-house technological innovation resources were complemented by technical resources within the adjacent maritime cluster. As a first mover in developing and using LNG-fuelled offshore service vessels, the company gained significant attention and goodwill from customers and other stakeholders, branding itself as an outstanding environmentally responsible shipping company. The

positive corporate social image did not, however, in itself provide for a market premium for the more environmentally friendly shipping services. The customers supported the environmental efforts in words, but were not willing to pay extra for them.

Key drivers and activities during the innovation processes in the case studies are summarized in Table 2.

Table 2. Key drivers and activities during the innovation processes

	Case A: Green operations campaign	***Case B: Development of LNG-technology***
	Strategic objective of implementing "*green operations*" to save fuel	Founder's spirit (*"business is more than profit"* & "*the sea is a renewable resource*")
	New project leader as champion/agent supported by CEO	Technology-*champions* (technical director – chief engineer - supportive CEO) and large technological staff
	Development of new creative business model aligning financial and environmental objectives	Key stakeholder engagement both on intra- and inter firm level (maritime cluster)
	Hands-on/minds-on collaborative effort (on-shore/off-shore) to enact the strategic innovation	High technological compentence and strong *technology-optimism*
	Design of reporting- and incentive system (green flag competition)	A strong collective belief in gaining competitive advantages through technological innovations
	Value-based leadership involvement	Environmental sustainabilty perceived as ethical (*"minds & heart"*) motivator and right thing to do based on technological achievements
Notes:	CEO (2nd generation leader of the firm) has *nautical education and prior experience as sea-captain*	CEO has a MBA and *maritime business-experience*

With reference to the CEOs' education and professional training as per the notes in Table 2, the observations made are only cursory, as no specific data indicate a relationship between the CEOs' professional background and the firms' innovation processes. However, drawing on earlier research (Gavetti & Rivkin, 2007; Lyles & Schwenk, 1992), one might nevertheless hypothesize whether a CEO with a nautical/navigational background might be more inclined to focus on innovation related to *ship operations*, and, similarly, knowing the technological focus of maritime operations, whether a CEO with an economics/business background might be relatively more easily influenced by a detail-oriented and well-motivated engineering staff to follow a *technological* path.

With the benefit of retrospect, in comparison to company A, the management team of company B seems to have had a technological bias and to have been relatively more influenced by the left brain (rationality) than the right brain (creativity) in choosing their strategic path.

6 Discussion and implications

The empirical findings indicate that Company A's success in achieving the strategic objective of an environmentally sustainable and climate-neutral offshore service rests on practical managerial and leadership skills resulting in optimization of the operation of the fleet. The firm was already in the forefront in caring for the external environment, albeit in a more or less unsystematic way, when the employment of a new project manager for the green operations campaign brought fresh ideas to the company's environmental endeavours. Notably, the project manager respected and took advantage of the existing maritime competence within the company and established through team collaboration a new business model establishing new rules, routines, and procedures to guide how work got done (Raisch & Birkenshaw, 2008), allowing 50% of the cost savings obtained by carrying out fuel-saving operations on board the vessels to be paid to customers and 50% to the Norwegian Rainforest Foundation. The contractual arrangement at the same time acted as a canvas for sharpening business ideas to achieve environmentally sustainable as well as profitable shipping services. The innovative business model provided target customers with offshore service that was both cost effective and environmentally sustainable. The value proposition created a win-win situation for both the customers and the external environment, and the firm successfully managed to establish team-based interdisciplinary practices and processes which encouraged innovative thinking. Also, because the organizational innovation processes rested on unique, idiographic, and *sticky* (von Hippel, 1994) organizational resources and capabilities, the innovation processes and the operational implementation were not easily copied by competitors within the offshore shipping industry. This was a solely managerial innovation requiring no additional technological investment.

Company B, on the other hand, did not manage to obtain a market premium on the basis of its LNG innovations, and the customers were not actively involved and encouraged to pay more for service provided by LNG-fuelled offshore vessels. Even though the company possessed excellent in-house technical resources and competence, and also cooperated extensively with technical partners within the adjacent maritime cluster, the company only to a limited extent took advantage of non-technical in-house or external managerial competences like marketing or finance which might have stimulated a dialogue around the possibility of supporting the technical innovations by altering the business model. Even though the company gained an image as an outstanding environmentally responsible company, the LNG technology solely led to fuel-cost savings based on the price difference between LNG and diesel fuel. Beyond the direct fuel-cost savings, no premium for more environmentally sustainable operations materialized even after 10 years. Thus, it appears that although the firm's strategy went a long way to improve environmental sustainability, it lacked the ability to entice customers to pay for this benefit.

From an organization perspective, the innovation drive was strongly technologically dominated, and was referred to as a "moon landing" venture among the participants. The chosen rhetoric indicates complexity and underlines the firm's goal of becoming a pioneer and first-mover in LNG-fuelled offshore service vessels (Gilbert, 2005).

There are several cognitive propositions for how firm B might give the impression to have implicitly downplayed if not ignored the necessity of being paid a premium for its

innovations. One is that the technical success of the project and continued exploitation of the LNG technology might be seen to have led the company into a cognitive *success paradox* (Audia, Locke, & Smith, 2000; Kyvik & Gjosaeter, 2015; March, 1991), blocking it from a more rigorous exploration of opportunities. Moreover, taking into account the size of the firm and available managerial resources, the technological success may thus have diverted attention away from also focusing on a strategy to connect the technological innovation with a customer need. This reasoning corresponds with the fact that company B got a lot of positive press attention as it developed the LNG innovation project, which was also supported by Innovation Norway, and it is possible that the combination of the above factors may have created somewhat of a "success bias" (Lovallo & Kahneman, 2003) and implicitly put a damper on the firm's entrepreneurial drive. This argument is also in line with recent views on how a business model perspective combining different disciplines and functions, both within the firm and externally, may positively contribute to a sustainable innovation agenda by opening up new approaches to overcoming internal and external barriers (Boons & Ludeke-Freund, 2013). Another cognitive trap is that the strong technological focus over several years may have created an organizational path dependence (Nelson & Winter, 1982) and a dominant technological logic (Prahalad, 2004), making it challenging for the firm to develop unique firm-based selling points requiring disciplinary competence from other knowledge areas. This situation is well illustrated by the technical director's off-the-cuff comment during the data-collection process that *the innovations in company A are not real innovations since they are not of a technological nature*.

Also worth noting is that the LNG technological advances for offshore service vessels were partly the result of a more or less open innovation (Bocken et al., 2014; Lee, Park, Yoon, & Park, 2010) process within the regional maritime *cluster* (Brunswicker & Vanhaverbeke, 2015; Brännback, 2004; Ernst & Kim, 2002), which at the time of the data collection was in an LNG-based sustainability mode. However, the entire innovation process was strongly technology driven and dominated by codified knowledge (Grant, 1996; Teece, 1998), and with technology-based interactions relatively easily copied by competitors. The openness of the innovation process and the continued close interactions with governmental authorities and commitment by regulatory bodies turned the LNG project into both a regional and national maritime prestige venture. And it is believed that the cluster-based technological networking further cognitively reinforced the path dependence (Sydow et al., 2009).

Clearly limiting company B's opportunity to benefit from its technological innovations was the lack of national and international rules and regulations demanding environmentally sustainable shipping by legislation (Huang & Kung, 2011; Sjaafjell, 2015). The reasoning here is simply that if international legislation required reduced emissions, this would more or less immediately reflect itself in the freight rates (the market price for transportation) due to a reduction in the supply of qualified ships.

The development in firm B compares quite sharply to company A's firm-based, more closed and intensely interdisciplinary and human-interaction-based (Barney & Wright, 1998; Gustavsen, Finne, & Oscarsson, 2001; Schaltegger & Wagner, 2011) process resting on idiographic and sticky tacit managerial and hands-on operational skills. In effect, the actions and activities within firm A may be seen as examples of practical ambidexterity (Birkenshaw & Gibson, 2004; Junni, Taras, Tarba, & Sarala, 2013),

where the land-based staff, in collaboration with the captains and crews, together explore operational manoeuvres to better exploit the vessels.

The research findings reveal that capturing profit from technological innovations presupposes a value proposition that responds to perceived customer needs and invites (through incentives) customers to take responsibility for negative externalities caused by the commercial services they are using. Transforming environmentally friendly technological innovations into commercial success constitutes a technical as well as a managerial challenge (Lindegaard, 2010; Sarkis et al., 2013; Tidd, Bessant, & Pavitt, 1997) demanding managerial capabilities to align strategy with an appropriate business model defining the *go to market* tactics (Teece, 2010). The business model must address the actual business issues at stake, reflecting an activity-system perspective that encourages systemic and dynamic thinking in business model design, instead of concentrating solely on technological choices (Teece, 2014), also keeping in mind that "a mediocre technology pursued within a great business model may be more valuable than a great technology exploited via a mediocre business model" (Chesbrough, 2010, p. 354).

The research illustrates that both managerial and technological innovations supporting strategizing of environmentally sustainable and profitable shipping is a dynamic leadership challenge (Jansen, Tempelaar, Bosch van den, & Volberda, 2009) and an emerging process based on experimentation (Khanagha, Volberda, & Oshri, 2014; Mansouri et al., 2015). Particularly in case A, the findings support the growing innovation literature's stress on the importance of a dynamic, multilevel, and multifunctional focus on innovation processes in organizational contexts (Jansen, Dusya, & Crossan, 2009; Kaplan, 2012; Teece, 2010) and emphasize the role played by managerial capability in managing innovation processes.

7 Contributions, limitations and further research

This comparative case study contributes important empirical insights into the challenges related to operationalizing environmentally sustainable innovations in offshore shipping. The research points to the importance of aligning the innovation drive with firm strategy and seeks to tie the process to the development of a key value proposition (Chesbrough, 2007). The results of the study emphasize that this goes beyond technology. As a mediating vehicle between a financial and a non-financial strategic configuration (Chesbrough & Rosenbloom, 2002), the development of a sustainable business model (Bocken et al., 2014) serves as a boundary-spanning instrument that goes beyond the more limited ambidextrous challenges related to balancing and integrating exploration and exploitation (March, 1991), providing for a complementary perspective on organizational innovation processes.

With reference to the research questions, the findings from the comparative case study analysis confirm the following:

- The firm-context (company culture, history, entrepreneurial origin) greatly matters and influences the *emergence* of the different sustainable innovation tracks. Also, timing of actions and activities, personalities of key personnel, knowledge-type and knowledge integration, and geographic positioning vis-à-

vis key members of the maritime cluster influence the innovation process.

- The flow of activities and actions is strongly firm and project leadership dependent. Consciously managed *interdisciplinary* knowledge-sharing processes seem to have a positive impact on innovation and tend to relate the process to commercialization and a potentially revised or new business model.
- The companies chose different sustainable innovation tracks partly based on historic track records (areas of expertise and leader's dominant logic), but also based on the hiring of external *sustainability champions* with highly different competencies. The hiring of enthusiastic champions supported by the CEOs created a self-enforcing sustainability process which developed and supported the different innovation paths (both project leaders were educated engineers, but with different orientations — one commercial and the other towards engineering).
- The main drivers and enablers for the innovation process in each of the firms are:
    - High level of nautical/technical and maritime operations knowledge as a starting point
    - High motivation to respond to a societal call for more sustainable maritime operations
    - Sustainability considered as ethical "right thing to do"
    - CEO/top-level support during the innovation process
    - Required resources and capabilities (in-house or external) made available when required
    - Active in-house champion as innovation project leader
    - Conviction that the innovation process would lead to competitive advantage
    - Inter-/cross-disciplinary approach to innovation
    - Both intra- and inter-firm (on regional- and cluster-level) positive image-building and incentives supporting the innovation process
    - Active networking during the innovation processes
    - Active key stakeholder engagement, including for external knowledge-sourcing, marketing, and image building

This study contributes to theory by applying varied management- and innovation-related theories to a still under-researched context, namely sustainability in the offshore maritime industry. The research context and findings of the comparative case study are useful for current management at both the top and medium levels and are seen as relevant for the teaching of engineering as well as management students. Though this was not an objective of this study, the outcome may also be seen as instructive for cluster management and industrial and regional network management, and as generally informative for policymakers.

The fact that the empirical observations in the study are limited to two firms within the same industry and limited to a Norwegian regional context may be seen as a weakness according to standard academic criteria. Though the cases provide details and understanding by its "thick description" (Geertz, 1973) of the innovation processes, the findings are still based on single-and exploratory case studies which might rise doubt about external validity. While the study has rigorously followed a protocol and a pre-

established research design conscientiously triangulating first- and secondary data over an extensive time-period, it is evident that it is hard to generalize the findings. It is, however, reasonable to believe that the findings of the study, due to the similarities between organizations and maritime operational environments across continents, also may be relevant for other offshore shipping firms being challenged to develop sustainable innovation strategies.

The outcome and learning from the study indicate several areas for further research. One is to further explore ambidextrous challenges (Giannopolou et al., 2011; O'Reilly & Tushman, 2004) in transforming sustainable innovations into reality, and to look closer at the role business models might play in bridging exploration and exploitation issues from a practical vantage point. Another is to investigate the role of governing rules and regulations promoting and constraining innovation of environmentally sustainable shipping projects. Finally, another avenue for follow-up research is to study the challenges related to collaboration among functional areas and disciplines within a firm and/or with external actors, with the objective of developing environmentally sustainable innovations as part of collective business model(s) in line with ideas from Salojarvi, Tarkianen, Ritala, and Sainio (2015). The proposed studies might contribute to the growing body of research within the innovation field focusing on how it is possible to profit from environmentally sustainable innovations (Amit & Zott, 2012; Boons & Ludeke-Freund, 2013; Droganova & Eyquem-Renault, 2008).

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