Large multi-national corporations (MNCs) – often vertically integrated having vast pools of internal R&D staff – could be expected to be those best positioned to make breakthrough innovations in response to the disruptive changes the world is facing. Yet they seem to fail at disrupting the world they do business in because of their internal mechanistic organizations operating in closed networks. Based on both literature studies and rigorous action research with a dozen MNCs that managed to co-create breakthrough innovations using a seemingly disruptive operational model involving university teams that both collaborate and compete, this article outlines a theoretical framework to analyze and understand how such collaborative competitions represent a new model for innovation in response to today’s business realities of VUCA. Our aim is to provide CMR readers with a new strategy and model for co-creating and exploiting disruptive technological resources in ways that enhance organizational resilience, agility and ambidexterity.

(Keywords: VUCA, Collaborative Competitions, Co-Creation of Breakthrough Innovation, Ambidexterity, Crowdsourcing)

“We have the best eggs, oil, lime and mustard in the world, but we are unable to move rapidly from science to actually do the mayonnaise. In today’s world of disruption, we need new operational models to move faster from science to sales.”
– Denis Aba, Head of the SBU, Nestlé Petcare
When Nestlé CEO Peter Brabeck-Letmathe launched an innovation competition among the five largest internal business units of Nestlé, Denis Aba, Global Head of the Petcare SBU, had a breakthrough innovation in mind – launching the first dogfood in the world based on natural functional food ingredients. Nestlé was clearly in a pole position to do this – being the first company to launch natural functional food ingredients in a yoghurt brand called Lc1, and having 600 food researchers in Vallorbe near Vevey who understood this area. In addition, Nestlé had become the number one in the world in pet food sales through the acquisition of Ralston Purina.

But some forces were potentially preventing Nestlé to be first in making this breakthrough. The Head of Research claimed that such a development was so complex that it would take two years to develop the product at the cost of $3 million USD and offered her conclusion by saying: “By the way, it will never work.” At the time, there was ambiguity within Nestlé as to whether pet-owners were ready for functional food for dogs and cats. Moreover, the pet food market was full of uncertainty and volatility – who would be first in launching functional ingredients and how would legislation develop.

Denis Aba had the money the Head of Research needed, but neither the time nor the tolerance for the internal ambiguity within Research. For Nestlé to remain number one, speed of innovation was key, but the Ralston Purina merger added complexity to the already large and rigid R&D organization. His solution was to tap into external research and support from different teams of researchers from universities and research institutes who were organized to both compete and collaborate to speed up the process of exploring and exploiting a breakthrough. The winning team came from
TNO Voeding, a research institute in the Netherlands. They developed the product in nine months at the total cost of $900,000 USD – less than a third of the suggested internal development cost and in less than half the development lead-time initially predicted. In fact, the new approach made such a strong impression on Peter Brabeck that the head of the TNO Voeding Team, Peter Van-Bladeren, was offered to take over the position as Head of Research. Nestlé went on to launch their new product – a nutritional enrichment consisting of fish oil and antioxidants. The product that is called Brain Protection Blend helps dogs and cats maintain cognitive functions so as to keep them as sharp as they can be as they age. Van-Bladeren made it his mission from then on to run all future breakthrough innovation projects using the same approach.

Dr. Van-Bladeren comments that: “I tried to use crowdsourcing a few times, but without meaningful results. Breakthroughs mainly happen when people with complementary skills and networks meet in person over an extended period of time”.

The Nestlé case illustrates how a new approach that uses competition among several external teams of researchers helped the company overcome challenges presented by a VUCA environment. Aba felt that even though his organization had great ingredients in-house, it had a hard time to “do the mayonnaise”. A new model was needed.

Proposing a New Model for Co-Creation of Innovation in a VUCA World

VUCA factors pull on innovation by complicating the context in which it must happen. In a volatile world in which the unexpected occurs with frequency, innovation is challenged by rapidly changing information, prices of materials, and changing consumer needs. Uncertainty leaves a residue of doubt and confusion as to
exactly where one should be going with R&D’s innovation efforts. It heightens the risks to innovate almost as much as the risks not to. A new approach that both saves time and cost of innovation seems essential in a VUCA world. Therefore, both a theoretical framework and further cases are necessary to understand how this approach works. It would also be useful to better understand when and how crowdsourcing and internet-based approaches can help companies overcome challenges presented by a VUCA environment? For these objectives to be reached, we first need to explore the effects of combining competition and collaboration.

Combining Collaboration and Competition

Groth, Esposito and Tse propose to use student teams to diagnose problems and synthesize solutions, and then act those out in the landscape, starting a dynamic exchange among the different teams.\(^2\) Such types of university simulation models leverage some of the principles that we see in the context of “collaborative university competitions.” In these competitions, those students who are best at collaborating and sharing knowledge with the other teams get the same financial award and recognition as the team that presents the best solution, thus fostering collaboration in the midst of the competition. A related response to VUCA is the development of governance sub-national and supra-national bundles together with “hybrid situations” whereby multinational corporations operate their research alongside local universities in countries with governance models supporting industry-university collaboration.\(^3\) We propose that the combination of collaboration and competition deserves managerial attention in response to the VUCA business environment we all face today.
The aim of this paper is to define an empirically-grounded theoretical model of co-creation based on abduction and reflection in action to illustrate how it can work in real world organizational and managerial challenges. The exploration and exploitation phases of innovation have historically been viewed as consecutive periods of the innovation process, yet they need to rely on fundamentally different types and structures of networks operating in polarized extremes, both in terms of organizational structure and relationship mode. In today’s VUCA business environment, however, companies have little time for consecutive phases. This paper proposes collaborative university competitions as a new model for ambidexterity allowing the exploration and exploitation phases of innovation to occur simultaneously.

For relevance, two case studies will follow, representing innovation challenges in relatively similar areas: New materials for healthcare and clean formulations for paint. For generalizability, we also include two brief case stories from fundamentally different industries in the analysis: The Nestlé case from the introduction, and a case on Porsche’s development of ceramic brakes available in the Appendix. The selective code of the core cases is identical: companies wanting to make a breakthrough innovation. The axial codes that help identify relationships among the selective code are: (1) realizing that a combination of external expertise and internal experience is required to make the breakthrough; (2) openness to try both crowdsourcing (See Table II in Appendix II for more details); and a network of carefully selected teams of university researchers engaged in a combination of collaboration and competition to accelerate co-creation of innovation.4

For rigor, our continuous involvement in the co-creation of the breakthroughs made it possible for us to collect a large trove of information from a limited number of
research units to gain a deeper understanding of how different types of networking across different types of networks made it possible to combine exploration and exploitation. Our data was collected over 16 years. The primary instruments in the data collection were personal observations and semi-structured interviews with company representatives using audio recordings that were transcribed. The method of reasoning in this research is mainly abductive, being a mix of deduction and induction. There was a continuous interchange between empirical data and theory, as empirical findings initiated the search for further theories. The purpose is theoretical development with a final stage of illustration of the theoretical framework rather than theory generation based on traditional grounded theory approaches. Details on how our research was carried out are available in Appendix I.

Proposing a New Ambidexterity Model for Concurrent Exploration and Exploitation of Innovation

Ambidexterity is most commonly about finding a productive balance between the paradoxical demands of stability vs flexibility and planned vs emergent approaches to strategy. Ambidexterity research especially stresses that in integrated industries dependent on disruptive innovation, long-term success requires excelling at both exploration and exploitation simultaneously. As leaders tend to gravitate toward the demand with which they and their stakeholders are most comfortable (e.g., exploitation), the need for exploration intensifies, fueling a strategic tug-of-war.

A strong focus on internal specialization in exploration can leave many people in R&D, marketing and manufacturing short of the cross-functional learning skills they need to manage the transfer and transformation of scientific knowledge into product
innovation. Therefore, the so critical and mainly tacit technological knowledge remains stuck in research for exploration – rather than being transferred into manufacturing for exploitation – doing the mayonnaise.

Current literature pays little attention to how exploration and exploitation of innovation seem to rely on fundamentally different types and structures of networks. This gap needs to be addressed to understand how these two types of networks can be connected and organized for concurrent exploration and exploitation of innovation in ways that offer a new model for ambidexterity. A core-concept going across the theoretical framework and the cases is that of co-creation, which first needs a clear definition.

**Defining Co-Creation in its Context of Related Terms**

Co-creation is a widely used term that requires clarity both in definition and context for sense-making use in this paper. Co-creation is value creation based on the involvement of actors from various disciplines and with different expertise. Many authors view co-creation as an active, creative and social process, based on collaboration mainly between producers and users that is initiated by a firm to generate value for the consumer. We have not found any literature relating co-creation to ambidexterity, or the ability to shorten time and cost of breakthrough innovation by running exploration and exploitation simultaneously – possibly because existing literature, reviewed in Table 1, deals with the term itself and what it means rather than analyzing the networks within which co-creation actually happens. Another reason may be that the term originated with exclusive focus on integrating customers into the innovation process.
TABLE 1: Defining Co-Creation in Relation to Adjacent Terms

<table>
<thead>
<tr>
<th>Co-creation in Relation to ...</th>
<th>Similarities</th>
<th>Differences</th>
<th>Main-Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaboration†</td>
<td>Collaboration and co-creation both possess a shared purpose of working together towards a common goal.</td>
<td>Collaboration, in contrast to co-creation, does not involve such an in-depth relationship among the participants. Rather, various actors add to a linear process through own contributions, whereas co-creation involves all participants simultaneously, ensuring a beneficial outcome for everyone involved.</td>
<td>Lee et al. (2012);</td>
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<td></td>
<td></td>
<td></td>
<td>Draelans et al. (2003); Ramaswamy &amp; Gouillart (2010);</td>
</tr>
<tr>
<td>Co-Opetition†</td>
<td>Parties collaborate towards a common goal.</td>
<td>The parties are competitors from the same industry whereby the fate of one person is interdependent with the other. Co-creation is value creation based on the involvement of actors from various disciplines and with different expertise AND a shared fate. Leadership of co-creation is, by nature, less hierarchical than that of co-opetition.</td>
<td>Brandenburger and Nalebuff (1996)</td>
</tr>
<tr>
<td>Co-opting Customer Competence†</td>
<td>Joint experimentation and learning among different parties. Very similar to the lead-user approach.</td>
<td>Exclusive focus on how customers can become an active part of the company’s resources in terms of enhanced collaboration between them, in aspects of e.g. knowledge sharing, skills sharing, active dialogue and willingness to experiment and learn</td>
<td>Prahalad &amp; Ramaswamy (2000)</td>
</tr>
<tr>
<td>Crowdsourcing†</td>
<td>Crowdsourcing and co-creation both leverage innovative ideas from people outside of the company. Using the vast knowledge of a crowd to work on a specific problem applied within an array of projects from citizen science to open source development of software.</td>
<td>Crowdsourcing outsources a task to an undefined network of people through an open call. Therefore, it does not focus on a social, interactive, creative and collaborative experience among selected participants. Tacit knowledge is not shared, because the experts never meet in person. The are not connected through the innomediary, which offers one-directional communication. The innomediary is a web-based platform, which is different from co-located teams of people working simultaneously for holistic mutual benefits.</td>
<td>Howe (2009);</td>
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<td></td>
<td></td>
<td></td>
<td>Bertini (2014);</td>
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<td></td>
<td></td>
<td></td>
<td>Laoto et al (2013)</td>
</tr>
<tr>
<td>Lead user approach†</td>
<td>The Lead user approach implies working together with people, who are willing to share their solutions to problems and to generate products for the mainstream market.</td>
<td>The Lead user approach is more product focused, as solutions usually have already been created. Co-creation implies both, a product-focus but also entails the creation of value through experiences.</td>
<td>von Hippel (2006);</td>
</tr>
<tr>
<td>Design thinking†</td>
<td>People from different backgrounds come together to solve problems; through its experimental nature the approach fosters innovation. It engages users in generating, developing, and testing new ideas.</td>
<td>Design Thinking is a more specific concept that has its origin in the creative field. With its interdisciplinary teams design thinking methods are often used in a co-creative process, but the concept as such is rather a good illustration of co-creation rather than being a synonym in any way.</td>
<td>Verganti (2013)</td>
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<td></td>
<td></td>
<td></td>
<td>Frow et al. (2015);</td>
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<td>Liedtka (2015);</td>
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<td>Brown (2008);</td>
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</table>

Over time, the conceptual understanding of co-creation in literature expanded to include the following four parameters: (1) involvement of at least two actors – who can go beyond users, (2) integration of resources that create novel and mutually beneficial value, (3) willingness to interact and co-create, and (4) a spectrum of potential forms of collaboration.
The Role of Tacit Knowledge in Co-creation

The co-creation networks deployed by the case companies we observed over the past 18 years use competition to accelerate exploration with universities, research institutes and sometimes also suppliers brought into the co-creation networks. This is an important contribution to the strategy and approach of co-creation networks. But a significant advantage of a co-creation network is also the sharing and leveraging of tacit knowledge, which is made possible through frequent physical interaction among the competing teams and the company organizing the co-creation network including collaboration-focused joint review-sessions. It is surprising that current literature does not include the so critical tacit dimension in the context of co-creation. This is, therefore, an important contribution of this paper.

As tacit knowledge cannot be codified, it typically cannot be transferred without transferring the knowing actor in person. Another critical enabler in this context is to facilitate the creation of social ties (personal relationships) between the transferor and the recipient – so as to prepare channels for tacit knowledge flows. Other factors that support the transfer of tacit knowledge are: similarities across knowledge bases, skills, organization models, relationship modes and incentive systems. We also believe it is important to distinguish between simple integration and real transformation of knowledge. Today’s VUCA reality raises both the complexity and uncertainty of business, which stresses the need for co-creation.

In some cases, crowdsourcing may also provide response to VUCA realities, but the question is when and how as crowdsourcing normally cannot handle the tacit dimension of co-creation.
Relating Co-Creation to Crowdsourcing

There are more than 500 innomediaries and crowdsourcing platforms available today. Inspired by Linux, Wikipedia, and OpenStreetMaps, to mention a few, numerous small businesses and big companies including Eli Lilly, Google, BMW, P&G, GE, Procter & Gamble, Boeing, DuPont, Colgate-Palmolive are using crowdsourcing with the ambition to generate new innovations. Eli Lilly, in particular, has been very active in this area and has helped spin out three crowdsourcing platforms: InnoCentive, Your Encore, and The Lilly Phenotypic Drug Discovery Initiative (or PD2). What all of these platforms have in common is that they rely on an unknown mass of people and broadcast an open call via internet reaching for external knowledge. Furthermore, their application of an unusual method and involving people outside of the organizational framework has gained quite some academic attention.

Sometimes, “grand challenges”, such as the XPrize and the Hyperloop Pod Competition, are coordinated through an internet platform, which thereby offer similarities with crowdsourcing. Also in these cases, the full focus is on competition among the “best teams” and there are no elements of collaboration among the competing teams. Appendix 2 provides a table showing examples of innomediaries/crowdsourcing platforms and how they are used. In the context of VUCA, it seems that crowdsourcing platforms have limitations in terms of the level of complexity that they can handle. This is possibly related to the fact that crowdsourcing platforms source ideas from dispersed and disconnected people preventing the transfer of tacit knowledge to take place. By contrast, co-creation depends on integrating people into different types of networks.
Open, Closed, and Co-Creative Networks

The basis for collaborative university competitions resides in utilizing open networks for exploration whereby different teams from universities, research institutes and sometimes companies compete against each other to develop the best solution to a specific innovation challenge. Another equally important dimension is that of temporary collaboration among the teams as they are brought into the coordinating company to focus on transformation and exploitation of the results. This requires a basic understanding of open and closed networks based on weak and strong ties. The open network is mainly about resource exchange of information, while the closed network focuses on social exchange, trust, and shared norms.25

An example of an open network is one in which firms have direct social contacts with all their partners, but these partners do not have any direct contacts with each other. This kind of innovation network stresses indirect linkage, has mainly weak relationships, and is loosely coupled. A high number of such non-connected parties, or structural holes, means that the network consists of few redundant contacts but it is often information rich, since people around the holes have access to different flows of information and knowledge assets that others are not aware of.26 The opposite is the tightly coupled closed network, where all partners have direct and strong ties with each other. Embeddedness in dense networks supports effective knowledge transfer and interfirm cooperation.27 A main-proposition of this paper is that this type of network is required for exploitation, but not well-suited for exploration.

Numerous research findings confirm that strong ties are positively related to firm performance when the environment demands a relatively high degree of exploitation, and weak ties are beneficial for exploration purposes and to prevent the network’s insulation from market imperatives.28
Based on the arguments outlined above, it seems reasonable to assume that strong and weak ties must ideally be complementary from the perspective of time, and that the structure of an ideal network should maximize the yield per primary contact. While weak ties are likely to accelerate development speed in early phases of exploration when the required knowledge is amorphous (ambiguity) and as yet unlearned (uncertainty), they may slow speed down in situations of high knowledge complexity where strong ties are required to support exploitation of innovation. As previously mentioned, we have not found any general literature, or particular network theory, offering strategies or models for performing exploration and exploitation simultaneously. In response to this knowledge gap, we propose three interrelated network levels with different foci:

- **Extracorporate Creativity Networks** with weak ties as primary sources of specialized knowledge and technology focused on exploration through collaboration with external partners – controlled through contractual agreements;

- **Intracorporate Process Networks** with strong ties for control through trust with focus on exploitation of innovation through strong linkages between R&D and Marketing & Sales (M&S) to reduce market uncertainty, and from R&D to Design & Manufacturing (D&M) to reduce complexity of commercialization; and

- **Co-Creation Networks** focused on interlinking the complementary creativity networks and process networks to better handle volatility and ambiguity. This is where and how cross-level interaction seems to happen for transfer and transformation of exploration into exploitation.

As summarized in Figure 1, creativity networks tend to have an organization model that is open and organic, but competitive, with a relationship mode that is weak,
sporadic and contract-based. The larger the number of structural holes (the higher the number of circles in terms of contractually connected university teams with entrepreneurial leaders spanning a high number of structural holes), the greater the exploration potential of the creativity network. As a polarized extreme, the process network has an organization model that is closed and mechanistic and can therefore be more collaborative within the closed organization that is having a relationship mode that is strong, systematic and increasingly trust-based over time.

**FIGURE 1**: Co-Creation Networks Spanning Simultaneous Exploration and Exploitation

The closed mechanistic dimension stems from the fact that process networks are typically found in large companies where organization charts, reporting routines and rigid processes tend to rule. In the middle, so to speak, the co-creation networks encompass and incorporate the polarized extremes of the creativity network and the process network in ways that make exploration and exploitation more concurrent than sequential. Ambidexterity happens through co-creation networks.
Re-Defining Co-Creation

This paper proposes five dimensions as critical to happen concurrently for the act of co-creation to be fully qualified and part of a co-creation network:

1. People engaged in co-creation need to have a shared fate – such as a shared reward system and incentive for success.
2. They are at least three (not two as proposed by current literature) actors who perform interrelated activities simultaneously in ways that bring results more valuable than the sums of the individual activities.
3. These interrelated activities include both exploration and exploitation.
4. Frequent physical interaction secures transfer, cross-fertilization and transformation of tacit knowledge.
5. The leadership model is based on heterarchy\(^{30}\) whereby the person having the most relevant knowledge for a specific phase leads the team during that phase.

Co-creation networks bridge two worlds that previously were assumed to be polarized and only engaged sequentially. We believe that the examination of co-creation networks will improve on current literature by understanding how collaboration and competition can be combined in mutually reinforcing ways; and by identifying how the different actors engage in exploration and exploitation simultaneously. This will enable us to draw theoretical and practical conclusions regarding the dynamic nature of co-creation networks and how these can make companies ambidextrous in response to today’s VUCA environment.

The case-section introduces Philips and AkzoNobel, but the case analysis also includes the brief case-stories on Nestlé’s breakthrough in pet food and Porsche’s development of ceramic brakes – available in Appendix III for interested readers.
Philips – Co-Creating an Extreme Breakthrough in Health Care

Philips Research is a global organization that helps Philips introduce meaningful innovations that improve people’s lives. They provide options in the area of health and well-being for both developed and emerging markets – where costs matter most.

Innovation Challenge

A great number of industries struggle with the scarcity of the rare-earth elements, which has made prices highly volatile and supplies uncertain in a market where demand has generally been increasing through the growing population.

The Innovation Challenge was concerned with the replacement of a rare-earth based material used in PET (Positron Emission Tomograph) scanners that serve the purpose of detecting cancer in human bodies. Due to Chinese pricing strategies, the rare-earth based phosphors ((Lu,Y)2SiO5:Ce) jumped in price six-fold each year. One PET contained over 30,000 crystals based on this rare-earth phosphor and, therefore, costs close to €3 million.

From 2000 to 2011, Philips Research invested more than €100 million to find a material that would replace the rare-earth based phosphors. This included both significant internal research efforts, but also collaboration with the best universities in the world. No replacement was found and the Global Head of Research & Alliances, Dr. John Bell, contacted us to support the organization of a collaborative university competition. Teams from Uppsala and Lund in Sweden as well as from Wroclaw in Poland were formed. The Polish team was the only one with prior experience in rare-earth phosphors and the Swedish teams added fundamentally new areas of knowledge in nano-materials such as polymers and ceramics.
Using at least one team with no prior experience in the area of nuclear research – and connecting them to a more conventional university research team with 30 years of experience in the field – triggered the co-creation of a fundamentally new material – a nano-ceramic-polymer that Philips never would have considered.

A potential barrier against the winning solution was the ambiguity presented by most senior scintillator expert within Philips Research, who was referred to as the Chief Science Officer (CSO) of Scintillators. Based on close to 30 years of research in the field with two PhDs and three Professorship positions, he “simply knew” that any material with the intended use in the PET would need to have high density. The nano-ceramic-polymer had much lower density than any material used so far, which is why he tried to stop this solution at each review. This caused ambiguity as not many researchers dared to challenge the “superior experience” of the CSO. At the final review, it was made sure that the CSO would get sufficient time with the nano-ceramic-polymer team so as to begin to see their perspective. As stated by the Global Head of Research & Alliances:

*When our CSO dropped his tie and started to play a guitar with the team from Lund, connectivity sparked and mutual understanding emerged. This kind of joint understanding would not have emerged through an internet-based competition.*

*Another reason that our senior expert finally accepted the nano-solution is that he could see how the other teams reacted when they saw the breakthrough*
being presented. The direct human interaction was essential here, because we could see the respective individuals’ body language and sense nuances that would not have been transferrable over the internet.

As stated by Dr. John Bell, bringing members from the winning team into the research lab in Eindhoven for three months secured human transfer of knowledge:

Finally, bringing several members from the winning team into our High Tech Campus (HTC) Eindhoven to join our Scintillator Application Team helped us accelerate the implementation of the new material.

Apart from carrying out an invaluable amount of research in the area, the winning team discovered a material that replaced the super-expensive rare-earth material. High luminescence for optimal image resolution could be obtained without cooling the new nanopolymer crystals, which significantly lowers the energy consumption of the new generation PET (and PT) scanners – while also making them noiseless.

The patent (WO2014/207144 A1) was granted by the European Patent Office less than 30 months after kicking off the collaborative university competition and less than 18 months after Philips’ Nuclear Medicine Priority setting meeting decided to file the original Invention Disclosure as a patent application. The Global Head of Research & Alliances commented that:

The fact that we had both an NDA with each member from each university team and a clear collaboration agreement with each university team gave our
scientists comfort to share everything they knew about what we had tried so far and why it had failed. Without this immediate immersion into the challenge, I doubt that the extreme breakthrough would have been possible within six months.

Another reason why innomediaries cannot solve extreme innovation challenges is that we are too afraid to make an understandable challenge-definition that provides enough background – as this can be seen by everybody on the internet. Working with carefully selected university teams that are all covered by NDA allows us to open up and describe the extreme innovation challenge in detail, including the research we made to try to solve it. This, we would never dare to share on the internet.

This case illustrates how the project could leverage the exploration benefits typical of the south-western extreme of our theoretical model and then gradually move into the north-eastern extreme for exploitation of the breakthrough. As experts from HTC Eindhoven were involved from day one in the creativity networks and members from the deserving university team transferred to the process network HTC, exploration and exploitation happened concurrently – in accordance with our widened understanding of co-creation.

The regular “collaboration for commercialization meetings” with the university teams transformed the CSO from barrier to believer regarding the new nano-ceramic-polymer.
AkzoNobel Case: Co-Creating a No-VOC Paint

AkzoNobel is the largest global paints and coatings company and is a leading producer of specialty chemicals. Having the world’s largest pool of R&D specialists in paint drives a tendency to try to do breakthroughs in-house.

Innovation Challenge

The Emission Challenge – No VOC (for Volatile Organic Compounds) was concerned with the discovery of both a method and ingredients to make state-of-the-art decorative paints environmentally friendly beyond any current industry standard. The paint industry has focused on reducing unwanted volatile organic compounds in paint formulations for over 20 years without finding a satisfactory solution. A lot of research resulted in patent applications, but very few discoveries led to commercialization. Who would be first? Regulatory bodies across the globe were raising the barriers. How far would they go and when?

Originally, AkzoNobel had selected to address the “opacity challenge” through a collaborative university competition. The company had suffered from increasing titanium dioxide prices – a main ingredient in most paints. However, two weeks before kicking off the challenge, the prices of titanium dioxide dropped, while several countries expressed intents to sharpen legislation against emissions from paint. Accordingly, top management decided to focus on the no VOC challenge instead.

Four university teams were selected for the collaborative university competition respectively from Naples, Nanjing, Lund and Eindhoven. Selection of the best suited teams was know-who based, leveraging social networks and personal recommendations as opposed to using citation indexes or patent performance. The
teams were highly complementary in skills and experience – all driven by strong entrepreneurs with good understanding of exploitation.

The proposed solutions were highly differentiated, because the different entrepreneurs were spanning very different structural hole in their respective home geographies. For example, the team from Lund reached out to a local paint development center, which allowed for concurrent exploitation of the results that were explored by the Lund-Team. The Chinese team identified new organic sources for the paint.

**Outcome (2012) – Breakthrough Polymers**

University research in compounds for low or no emissions is very far from making real paint. Therefore, we allowed for each team to conduct tests together with the locally available manufacturing plants of AkzoNobel in Sweden, Holland, China and the UK. As a result, one team had test samples of a new paint already at the mid-term review – just three months after kick-off. This paint had better performance properties than the best performing AkzoNobel paint ever developed in-house. The fact that one team had already brought such an extreme breakthrough to the mid-term review, triggered further creation and sharing amongst the teams. At the final review six months after the kick off, a new organic material from China – previously unknown to AkzoNobel – was introduced, and a new nano-based breakthrough natural material was unlocked, which had the potential to revolutionize the way decorative paints are formulated and set new standards for truly sustainable decorative paints worldwide.

The winning team was based in the Netherlands, which made regular interaction with an AkzoNobel manufacturing plant possible – thereby securing concurrent exploration and exploitation of the breakthrough. Based partly on the Chinese Team’s solution, an active bamboo ingredient has been added to a paint launched as Dulux.
Forest Breath. The bamboo ingredients capture and purify harmful air pollutants such as formaldehyde and benzine to keep indoor air fresh. It also contains natural tea tree oil extracts that kill germs and bacteria to create a healthy home environment.

Three patent applications were filed upon completion of the project and the winning team is now supporting the global implementation of the solution, including one industrial PhD. Head of IP, Christopher Ellis, mentioned that

*We first tried go develop a no VOC solution internally and then by working with the University X Molecular Institute, but failed to find an implementable solution and also ran into some IP ownership issues.*

*Bringing in four different university teams and combining collaboration and competition created more IP in six months than we normally do in six years – mainly because of the university teams, but also because it enhanced the productivity of our own R&D Team to be constantly connected to the inventive output from this project.*

The Head of Open Innovation for AkzoNobel, Harmen Kielstra, who was overall responsible for the No VOC project, stated:

*I have never seen such combined depth and speed of innovation in my life. I have always been open to trying new approaches and had tried crowdsourcing several times. They always delivered answers very fast, but never with the required depth to reach implementation. You get interesting ideas, buy no implementable solutions.*
Results and Implications

**VUCA Results from the Case Observations**

The cases illustrate how companies from fundamentally different industries have used a similar approach to build a new model for ambidexterity. The model allowed for simultaneous exploration and exploitation of innovation and thereby provided effective response to a set of clear VUCA realities – summarized below:

**TABLE 1: VUCA Observations from the brief Case-Stories and the Case-Studies**

<table>
<thead>
<tr>
<th>Volatility</th>
<th>Uncertainty</th>
<th>Complexity</th>
<th>Ambiguity</th>
</tr>
</thead>
<tbody>
<tr>
<td>National regulations for claims in the petfood market</td>
<td>Were competitors going to enter functional petfood?</td>
<td>Integration of natural functional food ingredients into the Product Technology Center</td>
<td>Would pet-owners be ready for functional food for dogs and cats?</td>
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<tr>
<td></td>
<td>Would there be new entrants?</td>
<td>Integration of Ralston Purina made intracorporate knowledge-transfer More complex</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No workable Solutions through Crowdsourcing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regulations on safety for brake systems</td>
<td>Who would be first – Mercedes or Porsche?</td>
<td>Material Composition</td>
<td>Using ceramics for brakes was outside of everybody’s competence</td>
</tr>
<tr>
<td></td>
<td>Who would have the strongest IP?</td>
<td>Surface Treatment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>First to file patent</td>
<td></td>
</tr>
<tr>
<td>Pricing and availability of Europium</td>
<td>Would any material be able to replace rare-earth phosphor?</td>
<td>Scintillators have very specific requirements</td>
<td>Cause and effect between density and material performance such as luminescence and image resolution</td>
</tr>
<tr>
<td></td>
<td>No workable solutions through Crowdsourcing</td>
<td>No one had succeeded in spite of 10 years of R&amp;D</td>
<td></td>
</tr>
<tr>
<td>Changing regulations in Volatile Organic Compounds Volatile prices of Raw materials</td>
<td>External collaboration without success: Neither through crowdsourcing, nor through collaboration with a Molecular Institute at a University in the US. Uncertainty regarding IP ownership stopped that project</td>
<td>Complex to move from a concept to a solution that can be produced</td>
<td>No company had managed to introduce a no VOC paint so it was unclear how customers would react to a paint with no smell at all.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Limited knowledge on natural ingredients</td>
<td></td>
</tr>
</tbody>
</table>
Volatility in regulations and/or availability of essential raw materials were important triggers of the breakthrough innovation efforts. There was uncertainty for all case companies in terms of who would capture the first mover’s advantage and raise the complexity to make a breakthrough by being first to file patents in the area of relevance. IP ownership is important to all case companies as it addresses some VUCA forces such as uncertainty and complexity. It also allows the case companies to either prevent competitors from copying their breakthrough innovations, or as Porsche does, to bring in licensing revenues. Uncertainty was further raised due to failed attempts to use crowdsourcing, significant internal R&D efforts and collaboration with isolated universities to get solutions to the innovation challenge. Breakthrough innovation caused a high degree of ambiguity across all cases as there was no prior art to learn from and it was unclear how the market would react.

**Deriving Organizational Principles and Management Skills from the Cases**

The model for collaborative university competitions should be sufficiently clear for a majority of innovation executives to apply it. The cases in this paper share the following six organizational principles and management skills:

1. Although the companies are the world leaders in their respective markets, VUCA realities drove them to reach for carefully selected external teams to co-create the required specific breakthroughs. In several cases the reach out for innovation support happened after a failure to create the solution in-house or through crowdsourcing.

2. All companies used several teams with different background and nationalities working on exactly the same innovation challenge. All companies shared the most
relevant past experience in terms of what they had done to try to solve the challenge and possible reasons leading to failure. NDAs and Collaboration Agreements gave the companies comfort to being fully open with such critical know-how and this seemed essential to reduce complexity and uncertainty of the challenge. Crowdsourcing did not offer this comfort to share past experience.

3. Although the university teams competed, the companies fostered and enforced a high degree of collaboration. The main-mechanism for this was to bring the teams to the company for sharing the different results and co-creation of exploitation steps. All companies also offered an award for the best knowledge-sharing team that was equally valuable as the award for presenting the best solution.

4. To transform the breakthrough findings into real innovations, the companies internalized the external teams as the co-creation process transitioned from exploration into exploitation. Joint reviews with co-location of the teams was essential to transform also the tacit knowledge from exploration into exploitation of the innovations. Parts of the winning team would often join the company for continued support of exploitation.

5. All innovations have awarded patents today that are solely owned by the companies thanks to a special IP regime (called the teacher’s exemption rule) that applied. Countries used for the university teams in the cases included Sweden, Netherlands, Italy, Poland, Germany, Australia and China. AkzoNobel initially collaborated with an institute at an American university, but discontinued this collaboration due to uncertainties in ownership of emerging IP.

6. Immediately upon filing of the patent applications, the deserving university teams were allowed to make publications on the co-created breakthrough innovations.
Implications on the Theoretical Framework for Ambidexterity

All four cases – long and short – illustrate how the companies begin exploration in the lower left (southwest) corner of the matrix, organizing the university teams in open and organic competitions whereby the teams could source complementary knowledge through sporadic contacts to peripheral colleagues. The results from this exploration were protected through a solid collaboration agreement and leakage was prevented through NDAs. In parallel, the companies secured exploitation by regularly bringing the teams to their manufacturing facilities, or the process networks, in the upper right (northeast) of the matrix in Figure 1. This part of co-creation was open exclusively to the appointed university team members. The atmosphere was collaborative with an increasing degree of trust emerging both among the competing teams and between the external team members and the internal exploitation-focused employees.

Comparing Crowdsourcing and Collaborative University Competitions – a Subject for Further Research

Compared to the approach illustrated the case companies, innomediaries limit the knowledge flow exclusively to explicit knowledge. In addition, innomediaries do not share the explicit knowledge among the different disconnected problem-solvers, who have no incentive for knowledge-sharing, nor any opportunity to learn from each other. By excluding both tacit knowledge and co-creation opportunities, innomediaries can merely source great ideas from lone inventors, but these do not seem to help companies respond to VUCA realities.

In collaborative university competitions, teams are measured and rewarded in respect to how they gather new knowledge, and how proactively they share their contributions with the other teams in real interaction time. In this spirit, prizes are
awarded not just for the best solutions, but for relevant knowledge shared with other teams.

Further research needs to be conducted on crowdsourcing projects that have actually provided adequate response to VUCA realities before we can draw further conclusions on the relative effectiveness of this approach.

**Managerial Implications and Generalizability of the Findings**

- CEOs, CIOs and Heads of R&D should consider collaborative university competitions as strategy and model to better respond to VUCA realities.

- The theoretical model presented in this paper suggests that exploration and exploitation happen in network structures that are paradoxical extremes both in terms of relationship mode and in terms of organization model. The co-creation network of collaborative university competitions covers both paradoxical extremes within one network – offering a new solution for ambidexterity.

- Collaborative university competitions seem applicable where crowdsourcing fails. The model of combining collaboration and competition can be applied also to research institutes and other innovation partners.

- The generalizability of our theoretical framework goes beyond the single cases, given that we have followed a total of 22 projects and organized five seminars with companies exposed to VUCA realities in which we have jointly reviewed and tested the applicability of the framework presented in this paper.

- This strategy and model are heavily based on bringing different experts and teams together. University teams can only be sourced from countries in which the teachers exemption rule applies. We need to better understand the rare(?)
exceptions in which the transfer of human knowledge carriers is not necessary to the same extent (for example, in pharmaceutical or software industries) to secure exploitation of the breakthrough. For such industries, innomediaries may be more cost-efficient instruments to perform breakthrough innovation in response to VUCA realities.

APPENDIX I

How the Research was Carried Out

Being immersed in the field of each case allows us to us methods of participant observation. In addition, we interviewed main-participants both from the companies and the university teams. These interviews were video recorded. For each of the breakthrough innovation cases, there was also at least one PhD and/or post doc student, who participated throughout the project to observe and document the co-creation process in the collaborative university competition so that we could triangulate data both for the detailed case-studies prepared for a book and for the case stories presented in this paper.

The theoretical framework is a further development of earlier work by Harryson focused on how companies and universities can co-create extreme breakthroughs by establishing and interconnecting creativity- and process networks through co-creation networks. We contribute to his model both by adding new theory and applying the enriched framework to five new cases with more details on the transformation process than in any of his own case studies. Our model makes a more detailed analysis not only of how the interconnection takes place but, more importantly, how the
knowledge is co-created and transformed into innovation using both open then closed networks – hence our choice to introduce the term ‘collaborative university competitions.’

To enhance the internal validity of our case, we had the cases reviewed by each company involved over several iterations. To enhance the generalizability of our theoretical framework, we also organized five seminars in which we jointly reviewed and tested the applicability of the enriched framework at ten additional companies involved in a large research project on best practices regarding knowledge transfer from external creativity networks to internal process networks.

While our total sample in the larger benchmarking project amounts to 22 cases of extreme breakthroughs, this paper presents two case studies and two case stories with focus on networking across multiple organizational levels to accomplish benefits of ambidexterity. The knowledge-creation dimensions combining collaboration and competition leverage insights from research projects with Ikujiro Nonaka and some 160 interviews made with Canon, Sony and Toyota in the 1990s analyzing how they achieved superior innovation impact with inferior R&D resources compared to their Western competitors. The four breakthrough cases presented in this paper were co-created between 2000 and late 2016. In addition, we ran a number of master thesis projects and two PhD projects – all following different parts of the four cases over an extended period of time.

In terms of case-selection, we therefore adopted a literal replication strategy where similar – not contrasting – characteristics were represented. The similarity we wanted was to have companies that had tried both the collaborative university competition approach, and at least one innomediary to accomplish a breakthrough innovation fulfilling the following characteristics:
• Being disruptive to the company’s respective industry by altering for the better the nature, design, market, functionality, capabilities of a product, material, service, or production method
• Delivering improvements and values far greater than the company expected to get
• Being patentable to protect the company’s leadership position and secure licensing revenues
• Building the company’s brand equity as much as it strengthens the company’s innovation leadership
• Being such a significant leap forward that it would not happen in isolation by a single inventor, or within a single company, because a unique combination of collaboration and competition leveraging both explicit and tacit knowledge was required to make it happen.

By applying our theoretical framework to these contexts, we want to ground our theory in reality – as opposed to developing a grounded theory.\textsuperscript{38}

During 2016, we also conducted interviews with some of the drivers of the cases presented in this paper. The purpose of these interviews was to add verisimilitude to the case stories and represent a wider network of the different actors across multiple levels in the case. These interviews also allowed us to follow up on the breakthrough innovations resulting from the collaborative university competition and gain deeper understanding of differences between these results and those from the internet-based approach that the companies (except Porsche) also had tried to find solutions to other innovation challenges.
Table 2: Types of Crowdsourcing and their use

<table>
<thead>
<tr>
<th>Type of Crowdsourcing</th>
<th>Main purpose of use</th>
<th>Complexity of challenge</th>
<th>General use platform</th>
</tr>
</thead>
</table>
| Prize contest based intermediaries | • to find brightest minds to solve problems  
• add diversity and creativity angle  
• create new products and service concepts based on ideas sourced from a high number of lone inventors around the world  
• Participants are not connected. Communication is one-directional | Complex technological, analytical, and scientific to societal to consumer product development orientated | - Innocentive  
- Ninesigma  
- Kaggle  
- Yet2.com  
- Quirky  
- Philoptima |
| Grand Challenges              | • to create open-source, competition projects involving multiple stakeholders  
• to add diversity angle  
• to find several different solutions/prototypes prepared by different competing teams | Highly complex technological, analytical, and scientific to societal.  
Sometimes involving the design of prototypes that are tested as part of the contest.  
Differs significantly from collaborative university competitions in that the teams are only competing, but they are not collaborating. This eliminates the potential benefits of ambidexterity.  
The principles of grand challenges are more similar to the architectural design competitions – pioneered in 448 B.C. to get design solutions for the Acropolis in Athens. | - Prizes for Global Health Technologies  
- Hyperloop Pod Competition (by SpaceX)  
- DREAM Challenges  
- FasterCures  
- Project Data Sphere |
| Health Social Networking platforms | • to aggregate vast amounts of data  
• nurture open-source/collaboration/co-creation minded projects  
• improve existing solutions | Rather simple to moderately complex | - PatientsLikeMe  
- 23andMe  
- Genomera  
- CrowdMed  
- CreateHealth.io  
- CureTogether  
- HealthTap  
- Webicina  
- HealthMap |
| Crowd Labor Intermediaries    | • to find a flexible and/or cheaper workforce  
• identify rare expert knowledge | Rather simple to moderately complex to rather complex | - YourEncore  
- Amazon Mechanical Turk  
- InCrowd  
- Medivizer |
| Game with purpose platforms | • analyze large amounts of existing data to advance scientific progress | Complex challenges that can be broken into smaller parts | - Foldit  
- EyeWire  
- Phylo  
- Biogames |
APPENDIX III

Porsche’s Breakthrough in Brakes

Would Porsche be able to set new standards in safety and reliability of brake-systems by introducing a fundamentally new material? Although they have a vast pool of R&D specialists in-house, Porsche will always make sure to have only one-third internal engineers and two thirds external experts in any team performing extreme breakthroughs to live up to the “innovation as usual” paradigm. If time is more precious than money, Porsche will use a collaborative university competition to accelerate the breakthrough.

Innovation Challenge

Through Porsche’s clear strategy to promote breakthrough ideas, Wendelin Wiedeking (CEO) wanted Porsche to be the first to commercialize ceramic brakes for street cars and with the strict deadline of the Carrera GT launch in 2002 – giving his team two years to do what no one else had done so far. Porsche pushed us to look all over the world for the most relevant technologies. Most important success factor was to bring the best brains into the Weissach-based ceramic brake team to secure 100% knowledge transfer and constant co-creation with the other team members. The team size was tripled starting with only 10 Porsche engineers. Proactive – sometimes close to premature – patent filing supported aggressive IP capturing from the co-creation process.

Having the openness to invite a manufacturing partner – SGL – into the team from day one supported acceleration of commercialization. In this way, Porsche had an exploitation network within the exploration network already from day one. The early inclusion of SGL into the process network in Weissach offered a unique opportunity
for Porsche to bridge a structural hole, because an entrepreneur within SGL was able to introduce the project leader from Porsche, Dr. Robert Volz, to a team of researchers based at a research institute in the US that had developed a unique surface treatment technology for ceramic disks used in the break systems of F16 fighters. Project reviews were open to such an extreme that not only the competing teams were presenting in front of each other, but leading experts from competitors like Mercedes were invited as well. These external experts added valuable knowledge and one of them was offered the opportunity to join the Porsche project team on a permanent basis. The co-creation network allowed Porsche to identify and hand-pick the best brains in the world.

**Outcome (2001) – World’s First Ceramic Disc Brake**

Porsche Ceramic Composite Brake (PCCB) – the World’s first commercially available ceramic disc brake with performance only found on Formula 1 cars: incomparable longevity, heat resistance and braking distance, 60% weight reduction, immediate brake contact and no fading. Porsche beat both BMW and Mercedes who had a half-year head start. They license the ceramic composite disc technology to competing car manufacturers for enhanced return on the breakthrough innovation and to increase the volume of ceramic discs manufactured by SGL. This, in turn, drives down the cost per unit so Porsche gradually can add the ceramic brake option to a wider range of their models.

Finally, through internal technology transfer Porsche was able to apply the ceramic material also to clutches in order to improve acceleration – not only deceleration.
END NOTES

1 For more insights as to why FMCG companies need to transform into FICG (Fast Innovating Consumer Goods) companies, see Peter Lorange and Jimmi Rembiszewski, From Great to Gone: Why FMCG Companies are Losing the Race for Customers, Routledge, 2014.


4 For more information on grounded theory development from axial codes and selective code based on the open codes from case observations, see Kathy Charmaz’s “Constructive Grounded Theory: A Practical Guide Through Qualitative Data Analysis.” Thousand Oaks: Sage Publications Inc, 2014.

5 The focus of our interviews was to generate depth of understanding, rather than breadth, mainly because we already had a holistic understanding of both the company and the extreme breakthrough case. For more perspectives on depth versus breadth through interviews, see H.J. Rubin, & I.S. Rubin, Qualitative Interviewing: The Art of Hearing Data (2nd ed.). Thousand Oaks: Sage Publications Inc, 2005.

6 Our case stories can be seen as a generative, evolving medium which are works in progress framed from a more extensive and detailed case-studies that are being prepared for a book. The case story method is a description process of lived experiences, which we as practitioners examine through narrative inquiry, storytelling, and re-experiencing the lived moments. For more details, see P.M. Jenlink, K. Kinnucan-Welsch, Teaching and Teacher Education 17, 2001 pp. 705–724; C. Mattingly, Narrative reflections on practical actions: Two learning experiments in reflective storytelling. in D. A. Schon (Ed.), The reflective turn: Case studies in and on educational practice, New York: Teachers College Press, 1991, pp. 235–257. Having documented the case stories, we also asked some of the key-persons behind the companies to check and reflect on their respective case. The purpose of these interviews was to add verisimilitude and to capture additional insights gathered by the practitioners in the years following the experience of collaborative university competitions. Some of these respondents were also able to share a comparative perspective between this approach to co-create breakthrough innovation and that of crowdsourcing platforms. This is linked to our interest in understanding when and how internet-based approaches can help companies respond to the VUCA realities.


Innovation as Usual (2005), op cit.

26 Ronald Burt (1992) op cit describes the social structural theory of competition whereby the contrast between perfect competition and monopoly is replaced with a network. The basic element in this account is the structural hole: a gap between two individuals with complementary resources or information. When the two are connected through a third individual as entrepreneur, the gap is filled, creating important advantages for the entrepreneur. Our argument in this paper is that the best suited university teams to be engaged in collaborative university competitions include such entrepreneurs.


29 Most research looks at learning alliances during exploration. A survey involving 536 Danish firms shows that the use of external knowledge sources is positively associated with opportunity exploitation. An important indication from this study is that the strength of this association seems significantly influenced by organizational designs that enable the firm to access external knowledge during the process of exploiting opportunities. The study does not provide details on how to organize for such knowledge access. See N. Foss, J. Lyngsie, and Shaker Zahra, The Role of External Knowledge Sources and Organizational Design in the Process of Opportunity Exploitation, Strategic Management Journal (April 11, 2013).


31 Researcher immersion throughout the cases combined with our involvement in the analysis and interpretation is built on the “development of experiential understanding throughout the research process over the time of study”.

32 By having video recordings, we added sources to our triangulation while also addressing the shortcomings of transcripts. See for example Kvale (1996, p. 167) who argues that “transcripts are decontextualized conversations. If one accepts as a main premise of interpretation that meaning depends on context, then transcripts in isolation make an impoverished basis for interpretation” S. Kvale, InterViews: An introduction to qualitative research interviewing. Thousand Oaks: SAGE Publications Inc. 1996. Through the videos more context and richness of information is communicated to the viewers.

33 For the benefits of triangulation, see Kaplan & Maxwell (1994); Miles and Huberman (1994)


35 The other ten members of our research project are/were: Bombardier, Bang & Olufsen, BMW, Gambro/Baxter, Nordic Mobile Company, SCA, Stora Enso, Tetra Pak, Procter & Gamble and Herenco – a company that acquired a packaging company from Tetra Pak.


37 For more information on the “literal replication strategy”, see G. Paré, Enhancing the rigor of qualitative research: Application of a case methodology to build theories of IT implementation. The Qualitative Report, 7(4), 2002, pp. 1-34.
