How disruptive are researching entrepreneurs?

On the innovative strength of German medium-sized companies

DIHK Deutscher Industrie- und Handelskammertag

IHK Deutsche Industrie- und Handelskammern

Study commissioned by DIHK, 2020, Dr. Reiner Nikula

Company Details

Author:

Dr. Reiner Nikula
reiner.nikula@t-online.de

Contact persons at the DIHK:

Felicitas von Bredow
vonbredow.felicitas@dihk.de
+49 30 20308-1108

Dr. Susanne Gewinnus
gewinnus.susanne@dihk.de
+49 30 20308-2213

Dr. Hermann Hüwels
huewels.hermann@dihk.de
+49 30 20308-2200

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Berlin | Brussels
Bereich Energie, Umwelt, Industrie

Department: Energy, Environment, Industry.

DIHK Berlin
Postal address: D-11052 Berlin | Address: Breite Strasse 29 | Berlin-Mitte
Phone: 030 20308-0 | Fax: 030 20308-1000

DIHK Brüssel
Representation of the German Chambers of Commerce and Industry to the European Union.
19 A-D, Avenue des Arts | B-1000 Bruxelles
Phone: +32-2-286-1611 | Fax: +32-2-286-1605

@ info@dihk.de
www.dihk.de

Graphics
Friedemann Encke, DIHK

Photos
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State
January 2021

Note of thanks

My special thanks go to Ms. von Bredow, Dr. Gewinnus and Dr. Hüwels from DIHK and the following chambers of industry and commerce, which conducted most of the interviews with the companies:

- IHK Chemnitz
- IHK Frankfurt am Main
- IHK für Oberfranken Bayreuth
- IHK Gießen-Friedberg
- HK Hamburg
- IHK Hessen innovativ
- IHK Hochrhein-Bodensee in Konstanz
- IHK Kassel-Marburg
- IHK Koblenz
- IHK Lüneburg-Wolfsburg
- IHK München für Oberbayern
- IHK Nürnberg für Mittelfranken
- IHK Offenbach am Main
- IHK Osnabrück-Emsland-Grafschaft Bentheim
- IHK Regensburg für Oberpfalz/Kelheim
- IHK Stade für den Elbe-Weser-Raum
- IHK Schwarzwald-Baar-Heuberg
- IHK zu Leipzig

Remarks

For the purpose of better readability, the simultaneous use of the language forms male, female and diverse (m / f / d) is omitted. All personal names apply equally to all genders. The statements in the text, especially the recommendations for action represent the personal opinion of the author.

Preface

Decision-makers in business and politics should never underestimate the following: curiosity-driven research leads to radical breakthroughs, and that a lot more often than expected. One cannot plan unexpected breakthroughs – quite simply because one cannot plan the unexpected. Still, there is a lot that can be done to ensure that unexpected discoveries occur and that a decision-maker is not driven by the discoveries of others. One can create the conditions for the discoveries to be made in one's own environment. One of these prerequisites is original research and attracting people to research that are ready to become involved in the unpredictable. Usually, only the best scientists are able to do this, because only the best scientists are real discoverers.

Another thing that is not to be underestimated: real breakthroughs in science will become relevant and valuable for economics sooner or later. As a physicist, I could not spontaneously name a single Nobel Prize winning physical discovery of the first half of the century that would not have achieved economic significance in the second half of the 20th century. But, on the other hand: each of these discoveries was ultimately the starting point of a radical technological and economic change. In the 21st century, the time span between discovery and economic commercialization will become even shorter, not least because every discovery is embedded in a world of growing knowledge, which simplifies and accelerates their implementation. The world is becoming faster. This is why the 21st century will come up with economic disruptions that challenge traditional industries and business models and change them radically. New economic sectors will emerge and change the world in unexpected ways.

The present study gives an insight into radically innovative activities of numerous entrepreneurs. Their products are able to create disruption in the sense of steeply increasing demand and fundamental changes in economic behavior. The DIHK is to be thanked for having commissioned this scientific study to explore the issue. An issue of great importance for the future welfare of our society. So, I wish this topic to receive a continuing high level of attention, including in politics. May the courage of innovators inspire future generations of entrepreneurs.

Stefan Hell

(Prof. Stefan Hell is the Director of the Max Planck Institute for Biophysical Chemistry in Göttingen as well as of the Max Planck Institute for Medical Research in Heidelberg and founder of the company "Abberior". In 2014 he received the Nobel Prize in Chemistry for his ground-breaking work in the field of ultra-high resolution fluorescence microscopy.)

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Management Summary

Germany and Europe can only prevail in the competition of global economic regions if they are faster in developing and commercializing new products and services. While incremental innovation improves existing products and processes in small steps, radical or breakthrough innovation creates a first-time technology for a new market. In the case of disruptive innovation, not the innovator but market demand is the driving force. Only when there is a steeply rising demand for a product and existing companies are being displaced, this results in disruption.

Business and science in Germany are indeed innovative, but do German products show disruptive qualities? How do leaps occur? What is typical for radical innovators? This study aims to shed light on these phenomena using empirical data. Therefore, interviews were arranged and analyzed with 70 highly innovative entrepreneurs from Germany.

Overview of results:

- Disruption results from the interaction of innovators and market forces, generally with large gaps between the launch of a new product and exponentially rising demand.

- A disruptive innovation with sharply rising demand and market-changing effect happens in Germany much more often than assumed. It may be elicited by radical as well as incremental innovators. External forces such as the Covid pandemic promote market-change and trigger increases in demand as game-changers.

- Disruption, that is market change caused by new products of the surveyed companies, happens in highly specialized B2B and hardly in mass markets. Habits change more often in manufacturers than in the population. Therefore, by far most of the disruptions "Made in Germany" are not noticed by the public.

- Radical innovators are very much different from gradually innovating companies. They may be described as researching entrepreneurs with a high level of academic education and delivering to market pioneers and early adopters. They maintain laboratories and workshops, work scientifically and are well connected to the academic world. This bond with science also emerges in their acceptance of impulses from research. Researching entrepreneurs are curiosity-driven, individualistic and their companies are smaller than those of incremental innovators. Spin-offs from research institutions may be included in this category as well.

- The percentage of entrepreneurs who are able to commercialize a radically new product to new markets is rather small. There are also no compelling reasons to develop radical innovations all the time. The receptiveness of the markets for fundamentally new products is limited. Customers must be willing to pay a higher price for a novelty before it is advanced to become a much cheaper mass market product.

- Research-based companies, with their dynamism and future orientation, do not only make a significant contribution to the innovative strength of society but also fulfil an indispensable economic function. They generate new technologies that are improved subsequently. Then the price is lowered by incremental innovators or themselves, which finally leads to mass products or the integration of new functionalities. Therefore, this creative core of economy should receive the necessary attention and support. The Federal Agency for Disruptive Innovation (SPRIND) and the IHK organization are able to provide decisive contributions in this regard.

To support the activities of researching companies, the study leads to the following recommendations:

1. **Recognize potentials: Discourse between politicians and researching entrepreneurs.**

An increased exchange between politics and the group of researching entrepreneurs supports the shared concern to maintain a highly innovative and competitive economy. Specialized contact points at the responsible ministries or meetings in high-profile formats such as award ceremonies or roadshows will intensify mutual understanding and joint action.

2. **Use synergies: Close cooperation between SPRIND and researching entrepreneurs.**

SPRIND is recommended to use the expertise of radical innovators, including their connection to potentially disruptive markets. In addition to the supervisory board, an advisory board of innovators could be useful. They may be involved in formats like podcasts or public events. Since disruption is more common in specialized B2B (business-to-business) markets, SPRIND may monitor ongoing disruption. Furthermore, a close cooperation with leading national innovation agencies will be most useful.

3. **Reinforce impact: Targeted support for researching innovators**

As a rule, one does not know beforehand which novelty has a disruptive quality. Development is therefore always combined with risk. Politics may use parts of established programs to support particularly risky projects with high market potential as a short-cut.

Further recommendations can be found in the final part of the study.

Introduction and background

The impulse to carry out the present study is connected to the decision of the federal government to set up the Agency for Disruptive Innovation SPRIND (Harhoff, Kagermann & Stratmann, 2018). It was planned as the core task of this organization to support projects that:

- are likely to be of great importance for the future, answering the most important challenges,
- promise new approaches that cross the boundaries of current technologies and practice and
- are basically suitable for companies to be commercialized in new products and services respectively used by the state on a large scale.

The core methodology was to be competitions, where submitted proposals were open to the involvement of experts and subsequently be implemented by competent program managers. In the interests of maximum efficiency, the project managers' freedom of action was emphasized with generous financial backing and long-term perspectives.

During this phase, the American DARPA (see below) was used for orientation, while other national innovation agencies were hardly taken into account. As preparation for a further discussion of this topic, the following slide contains the national innovation agencies of the leading countries in the order of the Bloomberg Innovation Index. Germany takes first place here, represented by SPRIND.

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Figure 1: National innovation agencies of the leading nations. 1st place: Germany, 2nd: South Korea, 3rd: Singapore, 4th: Switzerland, 5th: Sweden, 6th: Israel, 7th: Finland, 8th: Denmark, 9th: USA, 10th: France, 11th: Austria, 12th: Japan (Bloomberg Index, 2020).

A comparison of these agencies results in five major success factors:

- Consistent management of innovation
- Efficient cooperation between politics, economy, science and society
- Part of a national competition strategy
- Integration into global networks
- Focus laid on future market needs

On the basis of this common ground, there are national peculiarities. Vinnova in Sweden places great emphasis on involving citizens in the "Helix" approach: civil society, science and economy are moderated by the agency, whereas mixed teams work on regional issues.

The Japanese Moonshot Scientific Research and Development Program is the successor to ImPACT (Impulsing Paradigm Change through Disruptive Technologies), starting in 2020 and aims expressly at disruptive-destructive innovation. The program carrier JST (Japan Science and Technology Agency) supports innovation in general.

Business Finland and Israel Innovation Authority place great value on start-ups and growth. International cooperation is a major concern of Austria Wirtschaftsservice and Innosuisse, in the last example especially with KIAT from Korea.

The impulse paper criticizes the "conservative alignment" of the German innovation system without in-depth appraisal. Instead, this system is equated with the research system, as can be seen in the headline the following figure: "Actors of the German research and innovation system."

Figure 2: German research and innovation system (Website of the "Bundesministerium für Bildung und Forschung" Federal German Ministry of Education and Research, 2020).

According to this overview, research and development of companies play a limited role alongside public and private research as well as intermediary and political forces. On the other hand, there is no alignment with programmatic goals as recognizable in other national systems, likewise no coordination by an agency for general innovation. Classic research should therefore be turned into a modern innovation policy (Harhoff & Suyer, 2018).

In anticipation of the results of the present study, it should be mentioned that science and research are significant contributors to innovation, however there is little evidence to suggest that for highly innovative entrepreneurs the commercialization of research results of universities or institutes is the standard procedure (IFO, 2003). In the EU framework program for research and innovation "Horizon Europe", especially in the "European Innovation Council" from 2020, the classic division is to be found between scientists and entrepreneurs, whose early cooperation is to be promoted with the "Pathfinder" and "Accelerator" tools. This is countered by the fact, that spin-offs from science are undertaken by entrepreneurial researchers as Accelerators, and on the other hand, modern entrepreneurs are capable of being a Pathfinder. This is how the strict dichotomy of scientist and entrepreneur has been overcome in practice, as will be pointed out later.

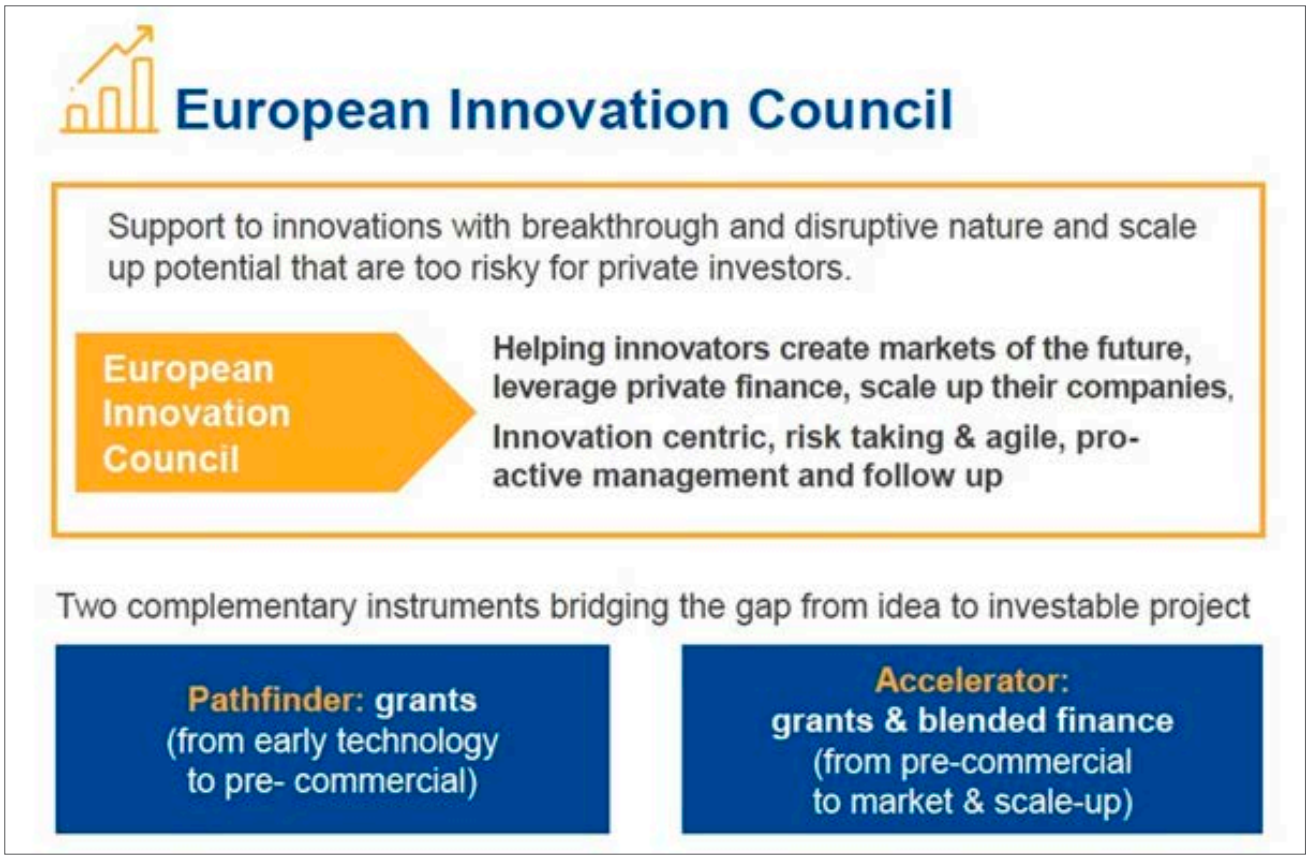

Figure 3: Pathfinder and Accelerator (ec.europa.eu, 2019).

In the key paper of the Federal Ministry of Education and Research (BMBF) on the "Agency for the promotion of radical-disruptive innovations" (2018)[1] there is a remarkable statement to be found: "Within this industrial core, many companies, however, develop preferably evolutionary innovations. Particularly disruptive innovations or radical innovations, which are characterized by new, market-changing business models or radical technological innovations, are increasingly coming from other countries in the world, such as the USA or China."

The industrial core is seen here as deficient. In another quote, it is held responsible for not commercializing the ideas and inventions of researchers (Wagner et al., 2018). This statement is often repeated in different formulations and hints at an "implementation problem" of research results. As will be demonstrated, this assumption is hard to defend.

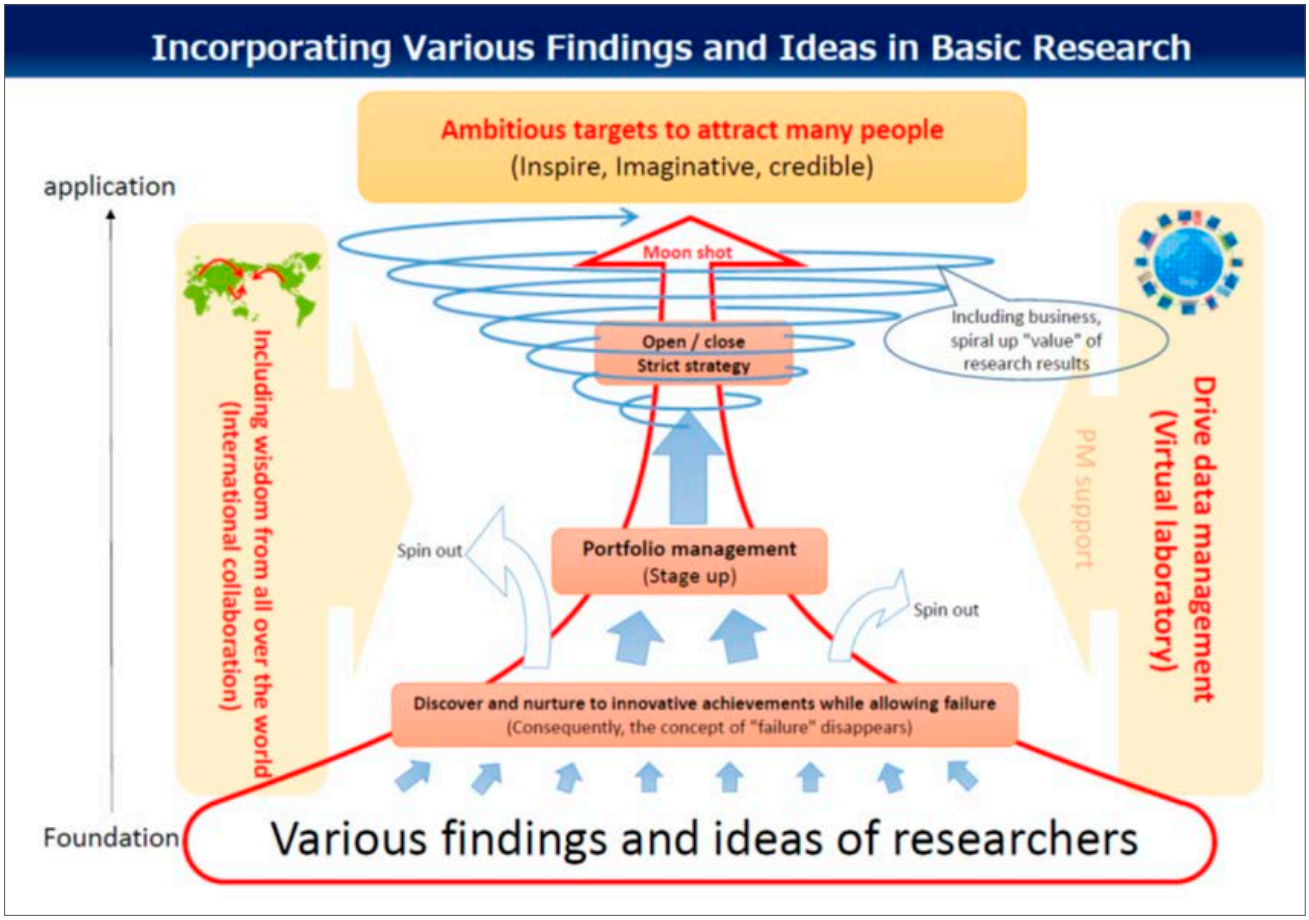

Figure 4: Moonshot program (Cabinet Office, 2020).

The American Defense Advanced Research Projects Agency (DARPA) takes on a model function in the key paper mentioned. It applies a diversity of approaches within the programs (DARPA, 2020). In the "end-game" perspective, products and processes desired for the future are defined in the first step (not research results), the necessary technologies are derived and finally implemented in interdisciplinary teams (Dubois, 2003).

Japan's Moonshot program (2020) establishes a complex structure that cannot be reduced to the implementation of research, either. The term "researcher" should be defined in this context. In a personal communication, it was pointed out that research takes place both in science as well as economics.

To explore these aspects, one should consider the history of innovation theory. The creator of the concept, Schumpeter (1947), emphasized the central role of the entrepreneur as a creative destroyer (OECD and EUROSTAT, 2018).

Many years later, the "linear model", formulated in the 1980s (Kaldewey, 2011), focused on research, as shown in the following figure.

[1] *https://www.bmbf.de/files/Eckpunkte%20der%20Agentur%20zur%20F%C3%B6rderung%20von%20Sprunginnovationen_final.pdf*

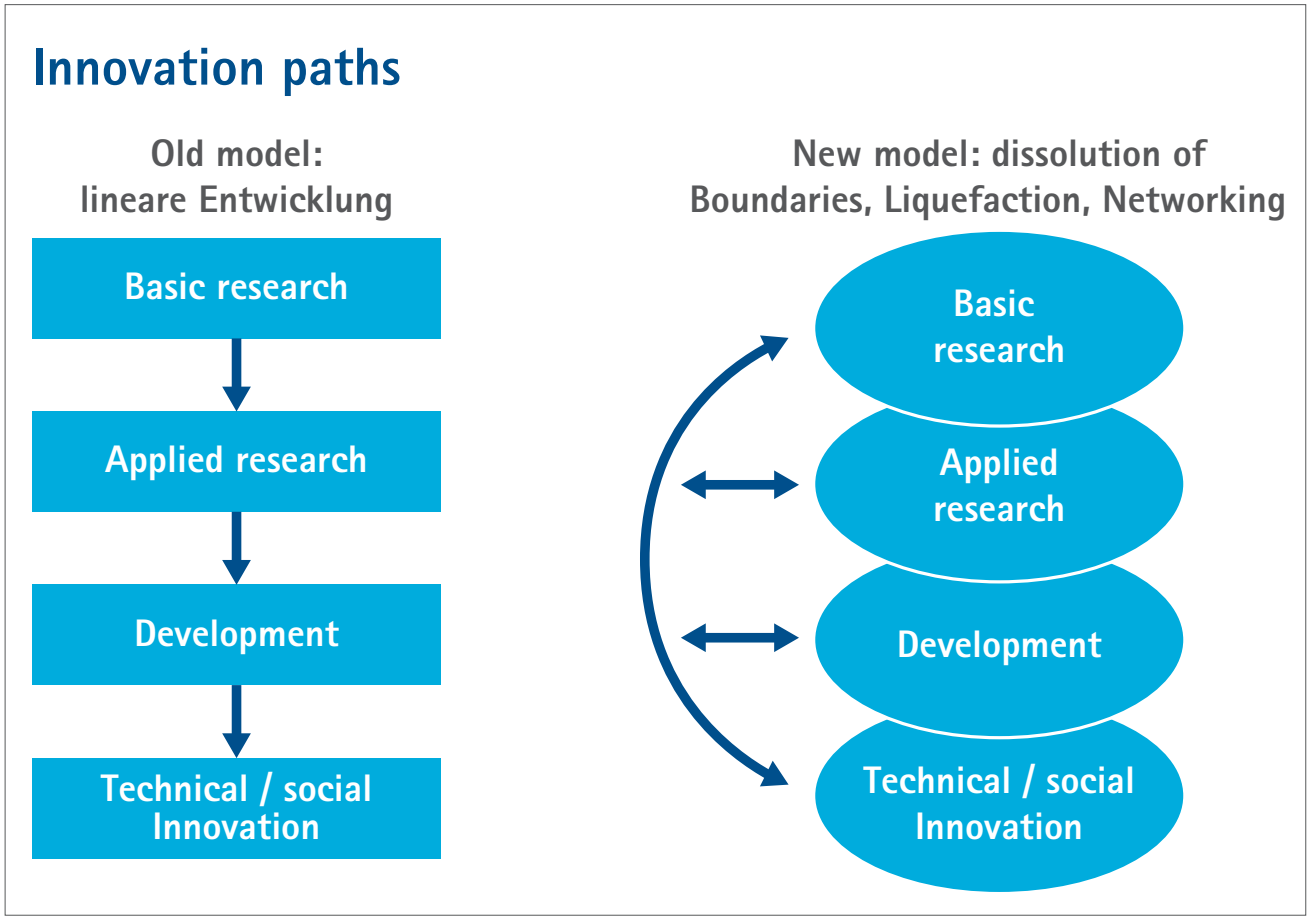

Figure 5: Linear model (Fagerberg, 2006; Berkemeyer & Junker, 2013. Graphics: Friedrich-Schiller-Universität Jena).

In the old model, innovation starts with basic research, proceeds with applied research and development to finally reach the stage of a product. The new model describes a recursive and non-linear process with many iterations.

The linear transfer of research results has been replaced by this dynamic approach, including spin-offs or licensing from science. The complex, dynamic interaction of industry and research has been described in detail (Harhoff, 1998) and should not be reduced to the unidirectional vectors of the "old linear model".

Inspired by American authors (v. Hippel, 2005), the focus turned to the "intelligent users", who are able to improve products as well as to innovate successfully on their own. A well-known example is Alois Ruf's electric Porsche from 2008. Lead users, as in the Design Thinking approach, are regularly included in research and development nowadays (Müller & Schroiff, 2020).

The overview of national agencies already showed the complex interaction of different actors in the development process of new products. As another example, Max Planck Innovation not only supports high-tech initiatives but also socially relevant projects (see above).

"Open Innovation" (Zerfass, 2010) emphasizes a dynamic process of gradual alignment towards a promising novelty, using numerous sources of information also outside of the company. This hints at an important function of professional communication.

Recently, much effort has been taken to work on the benefit of artificial intelligence to accelerate innovation (Hölzl, Tiberius & Surrey, 2020). The application of modelling and machine learning definitely makes innovation more powerful.

The present study was designed taking these concepts into consideration. First, the establishment of an Agency for Disruptive Innovation deserves support. Subsequently, the intention was formed to find out empirically, if in the German economy, especially in small and medium-sized enterprises, innovators generate radical novelties and thereby elicit disruption in the sense of a steeply rising market demand. Incremental innovators were chosen as the comparison group. Before the collection of data, research had to be conducted to clarify the terminology of radical and disruptive innovation as well as non-linear market transformations.

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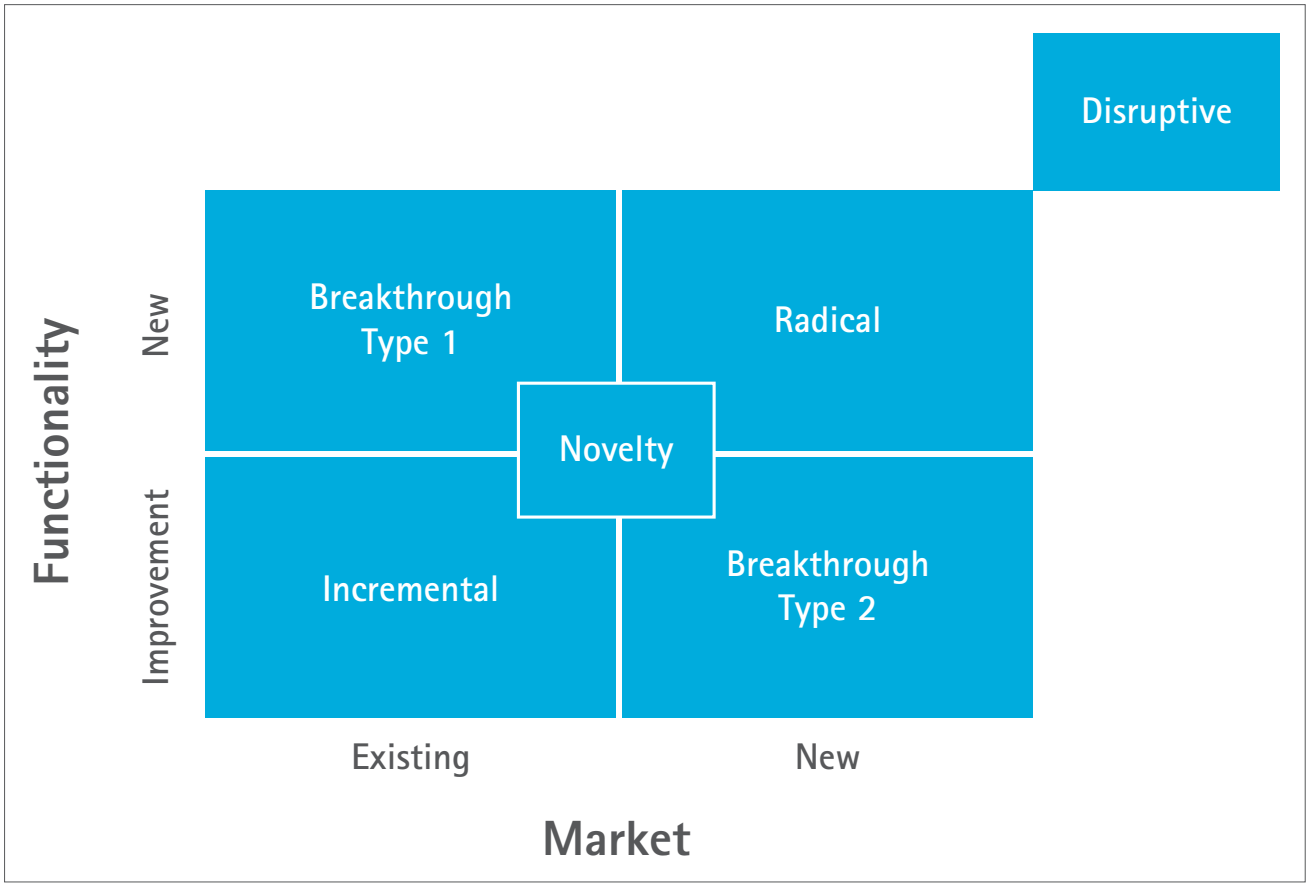


Figure 6: Categories of innovation (own, cf. Rothaermel (2012))

Definitions in the context of innovation

Innovation

Starting with Schumpeter's definition (revised in 1947): (Innovation) "... is the doing of new things or the doing of familiar things in a new way", it is generally accepted that the ability to repeatedly produce something new is an economic success factor. Furthermore, the necessity of "creative destruction" has been accepted.

Viewed from a modern perspective, three forces contribute to this effort. While originally the crucial importance of the entrepreneur as an innovator was emphasized, starting with Rogers (2003) the defining role of the market has been worked out. The third strategic factor is the ability and readiness of academic and industrial research to make substantial contributions to application-relevant issues.

These factors are involved in a dynamic interaction, in which positions may change. Research itself is a market for entrepreneurs, innovators are customers for suppliers, a campus may produce cars (RWTH Aachen University) and thereby turn into a competitor for industry. A differentiation of "innovation" has taken place in a similar way.

Incremental innovation

Evolutionary or incremental innovation improves existing products and processes in small steps for an existing market. Customers, especially of digital products such as operating systems, expect regular updates, which are understood as signs that the manufacturer is committed to improving the product.

This also applies to modern electric vehicles that receive additional features as downloads. This is also how the capacity of hard drives has been increased continuously until the Solid-State Disks SSD or the SD cards put an end to the life cycle of the HD.

Breakthrough innovation

There are two cases of breakthrough innovation: a technological breakthrough is achieved by a first application of a technology. Examples are the airplane, penicillin, the "Sputnik" satellite, or SSD storage. Breakthrough innovation in production is generally not noticed by end users, such as 3D printing or waterless paper-production, which, however, is enabled by the application of a new technology.

In comparison to that, entering a new market is called a breakthrough innovation, too. In a recent example, a textile company has become active in the concrete reinforcement market of construction industry, just as a manufacturer of transparent ceramics developed a transparent coin for Lithuania without changing production.

Radical innovation

Radical innovation uses a first-time technology as well as a new sales market. A classic example of this is the transition of Apple as a computer specialist to the smartphone mass market with the introduction of touch screens as a new surface. VW currently applies new technologies in the recycling of batteries, while BYD, after starting to produce batteries in the early 2000s, has become one of the leading manufacturers of electric passenger and commercial vehicles.

Disruptive innovation

Disruptive innovation (Christensen, 1997) is defined in interconnected ways. Originally, this process begins with a high-priced, exclusive novelty that is developed into a mass product through a reduction in price. The formerly hardly affordable computer has now taken on the form of mobile phones and has entered smart products. In this way, small companies can conquer significant market shares to threaten established manufacturers.

With the establishment of the "Agency for Disruptive Innovation" in 2019, the discussion of the term "disruption" has been intensified. On the one hand, this means the sudden increase in the performance of a novelty compared to its predecessor. On the other hand, it refers to the sudden transformation of a market, resulting in a non-linear rising demand.

The term "game change" refers to rapidly modified market rules. The current pandemic has triggered numerous transformations as such: the sale of fleece and mouth-nose masks has multiplied.

Markets do not change immediately after the introduction of a new product in general. As an example, the mass demand for cars increased, only after many decades, not until the late 1940s.

This market dynamic should not be reduced to the linear supply-demand mechanism. The novelty always has to prevail in the competition with established products. Furthermore, innovation communication (cf. Nordfors, 2003) has demonstrated that the potentially volatile response is influenced by the communication of market participants. The public visibility of new products plays an essential role, too.

The digital information accompanying the new product can nowadays quickly reach large target groups and may contribute to a large-scale rise in demand. In B2B, it has become normal to supply advance information in the highly specialized sub-markets to announce an expected novelty. A glimpse of future functionalities can be achieved by virtual demonstrations (Moore & Benbasat, 1991).

Technology acceptance (Plouffe, Holland & Vandenbosch, 2001) refers to the simplicity and usefulness of the first application of a novelty. Subsequently, activities are triggered in the market networks (Beck, Beimborn, Weitzel & König, 2008). User comments may, in the sense of a chain reaction, ignite the interests of other possible customers.

The interaction between the novelty and the digitized, dynamic markets eludes control of an innovator and his business model. Rather, it is all about the transformation of complex systems including innovative entrepreneurs.

Methodology

In the first step, this study aims at finding radical as well as incremental innovators, and at characterizing and/or differentiating them respectively. Based on literature, a large effect size of group membership was expected, so that personal communication with innovators was chosen as a method to collect multiple kinds of data.

Because of the Covid-19 restrictions, structured interviews took place by phone. For this purpose, the DIHK prepared an online guide. The answers were protocoled and stored in a cumulative file.

20 innovation consultants of the IHKs, two DIHK experts and the author of the study conducted the interviews. The procedure was practiced in a detailed, documented training, recorded on video and discussed.

The data was to be obtained in four different categories: objective data (e.g., number of employees, turnover), subjective data with given options (e.g., „What was the decisive impulse for the development of the novelty?"), open questions (e.g., "How do you define innovation?"), and assessments of the interview by the interlocutors (e.g., "To what extent did the interviewee express long-term goals?") (cf. Nikula, 2020).

Use of data analytic tools

The program package SPSS Statistics 26 served as a basis for statistical analytics, in which t-test, chi-square, Fisher test, factor and discriminant analysis were used.

For the evaluation of the free answers to the open questions, "Semantha" of thingsTHINKING was chosen, which applies artificial intelligence to sort free speech into a sematic space according to similarities of meaning, as will be shown in the results section. Following the formation of groups, the content of these clusters was analyzed.

Selection of the sample

For methodological reasons, only highly innovative companies were targeted. They were not classified at this point and it could be assumed, that many of them would be radically innovative.

Companies were selected that have repeatedly brought radically innovative or to a large extent incrementally innovative products to the markets. Furthermore, indications of a surge in demand were to be found.

The radically and incrementally innovative types of companies are to be regarded as equally important. It is worth remembering that radical novelties are incrementally improved to turn into series products. In other words, every serial product of today started its life cycle as radically innovative. One of the best examples is the automobile, that was marveled at in the 19th century. Seat belts, ABS or driver assistance were accepted after many initial controversies. And autonomous driving will become part of everyday life in the near future.

In the first phase, DIHK experts and the author collected a list of companies that was expanded by innovation consultants of the IHKs. Furthermore, innovators recommended other companies and the winning of awards or rankings provided additional candidates. However, in each case, the proof of highly innovative products was decisive, not a collection of indicators such as expenditure for research and development.

After careful reviews, the pool contained 161 companies. Each of these firms could be characterized by innovative products, many by the entry of new markets or a sudden surge in demand. The selection did not regard business sectors, regions, age, gender (16 women), education level or other criteria. The list does not claim to be complete in any way but was accepted by the mentioned experts to be representative.

Description of the sample

Three of the 16 women in the total sample could be interviewed as well as 47 men. The following table resulted for the sectors as defined by the Federal Statistical Office:

Industry sectors	N
Trade	01
Construction	02
Production	59
Gastronomy	01
ICT	04
Traffic	00
Service providers	03

The dominance of production was not intended. It cannot be concluded that manufacturing companies are fundamentally more innovative than others.

The companies were distributed across the federal states as follows:

Federal state	N
Baden-Wuerttemberg	09
Bavaria	15
Berlin	05
Brandenburg	03
Bremen	00
Hamburg	03
Hesse	07
Mecklenburg-Western Pomerania	01
Lower Saxony	05
North Rhine-Westphalia	12
Rhineland-Palatinate	02
Saarland	00
Saxony	06
Saxony-Anhalt	01
Schleswig-Holstein	00
Thuringia	01

This overview reflects the regional number of companies who agreed to be interviewed and does not permit any conclusions about the innovative strength of the respective federal states.

The classification of turnover is based on the SME range and results in the following distribution:

Turnover / year	N
< 1 million	17
1 < 5 million	11
5 < 10 million	07
10 < 20 million	09
20 < 50 million	08
> 50 million	18

On average, the small and medium-sized companies achieve a turnover of more than €50 million with the hint of a U-shaped distribution, whereas the number of employees is well below that of large companies.

The following table summarizes the assignment to the "Tier" system, taken from automotive suppliers. Here, the original equipment manufacturer (OEM) forms the top of a pyramid, system suppliers deliver functional components such as doors and parts partners produce non-functional components to be integrated into systems, other manufacturers supply unspecific materials. Service providers play a special role, their contributions are not to be found in the products, still, they support production or distribution significantly.

Tier system	N
OEM	23
Systems	22
Parts	12
Materials	04
Service providers	09

There is a clear predominance of companies who are OEM or provide systems. Material manufacturers in particular are hardly represented. The close connection to customers is an important driving force for innovation, which is confirmed in this study.

The market segment of customers is derived from the diffusion theory presented (cf. Rogers, 2003). Pioneers purchase high-priced first-available novelties well in advance of the mass market. This includes electric vehicles such as the Tesla Roadster, if bought in 2008, or portable music players with 32 bit and 384 kHz.

Early adopters orientate themselves towards the pioneers but are not ready to accept the high entry price and prefer to wait until practical use has been demonstrated by the pioneers. The early majority is supplied at significantly lower prices, while late majority is ready to buy when the formerly innovative product has found its way into everyday life.

The following distribution emerges:

Market segment	N
Pioneers	17
Early adopters	17
Early majority	26
Late majority	10
Laggards	00

The vast majority of companies supply market segments ahead of late majority. In the Gaussian distribution of diffusion (cf. Rogers, 2003) the averaged focus is positioned before early majority and thus in the market segment that is considered as fast-moving.

Media	N
Nationwide	28
Technical	38
Regional	04

Technical reporting predominates, followed by nationwide interest, while the regional press hardly plays a role. Here, the important function of trade press is obvious, while the regional media does not really seem to take any interest in local companies coming up with new things.

Finally, objective characteristics of the interviewees are listed, first the age:

Age	N
<= 30	01
<= 40	16
<= 50	20
<= 60	26
<= 70	06
> 70	01

The average age of highly innovative entrepreneurs is about 50 years. Accordingly, entrepreneurial experience seems to be an important prerequisite for innovation.

With regard to the level of education, the following results:

Education	N
Secondary school	02
High school	02
Bachelor	03
Master / Diploma	42
Doctor	19
Professor	02

Here, the growing academization of the economy over the past decades emerges. In particular, the number of academic titles is remarkably high.

Finally, the position of respondents is presented:

Position	N
CEO / owner	47
Managing director	09
Manager	10
Employee	04

The vast majority of the interviewees are to be found at the top management level, even the employees are innovation-project leaders

Division of the sample into two groups

After a critical reduction of 161 to 149 companies, these were contacted. 70 persons agreed to participate in the study. The final division into incremental or radical innovator was undertaken following the final interview by experts of the DIHK and the author of the study. This assignment was based only on reports about novelties, including those from customers. Indirect indicators, such as R&D expenditure, were not take into account.

The interviewees of the experts were classified by the author prior to data analysis. His partners were grouped by the DIHK, those of the IHK consultants were done by DIHK and the author. This procedure made sure, that no interviewer knew the classification of companies beforehand. Furthermore, the participants were informed, that this study was concerned with an analysis of highly innovative companies. Hence, the independence of the two samples was ensured.

As for the reasons for refusing to take part in this study: the majority of the rejecting companies generally do not take part in any data collection.

Comparison of incremental and radical innovators

Objective data

The objective variables of the two samples were compared by the t-test (see SPSS explanations). This procedure checks mean value differences in normally distributed samples that are distinguished by a clearly defined, independent feature. The items are presented, also the type, N provides the number of companies, the mean is calculated arithmetically, error p stands for the probability of error in the statement that the groups are distinguishable, the significance gives * for an error probability of less than / equal 5%, ** indicates 1%, *** to 1‰. Under RI> II the significant results are given that the values of radical innovators are higher, II> RI accordingly for higher values of the incremental innovators. In the variable "Tier", the service providers have been left out in order to build a ranking sequence starting at materials to OEM.

Group comparison: 1 = radical, 2 = incremental				error p	Sign. Results	
Characteristics	Typus	N	mean		RI > II	II > RI
Turnover	1	40	3.05	0.015		*
	2	30	4.07			
Employees	1	40	3.00	0.020		*
	2	30	3.87			
Tier	1	40	1.94	0.469		
	2	30	1.96			
Market segment	1	40	2.15	0.005	**	
	2	30	2.77			
Age	1	40	3.30	0.394		
	2	30	3.37			
Education	1	40	4.30	0.044	*	
	2	30	3.93			
Position	1	40	1.35	0.007	**	
	2	30	1.90			

The incremental innovators achieve a larger turnover and employ more people than the radically innovative entrepreneur. This result can be explained by the diffusion theory (Rogers, 2003). Incremental innovators tend to supply the early majority and later segments, while radical innovators focus on the pioneers and first-time adopters to achieve higher prices with far lower quantities.

First qualitative differences become apparent and are confirmed by the following point: radical innovators supply significantly earlier market segments than incremental ones.

Type	Radical	Increm.	Total
Pioneers	14	03	17
Early adopters	09	08	17
Early majority	14	12	26
Late majority	03	07	10

The level of education among radical innovators ranges between master's degree and doctorate, while the incrementals are centered around the master. Radically innovative entrepreneurs therefore have accumulated a high level of scientific experience.

Educational level	Radical	Increm.	Total
Haupt-/Secondary school	00	02	02
High school	01	01	02
Bachelor	01	02	03
Master	25	17	42
Doctor	11	08	19
Professor	02	00	02

Even more significant is the finding that radical innovators are much more likely to be CEOs or own their business. Innovation seems to be the task of the top managerial level.

Position	Radical	Increm.	Total
Owner/CEO	29	18	47
Managing Director	08	01	09
Manager	03	07	10
Employee	00	04	04

With the acquisition of objective data, significant differences were detected. In contrast, the position in the supplier hierarchy and age seem to be irrelevant. It will be interesting to find out whether differences may be proved in subjective statements of the groups.

Subjective statements

The following questions provide possible answers that refer to factors considered as relevant in innovation theory and policy. Approval is coded as 1, negation as 2. The statistical method is the Chi-square test, while significance was calculated using the Fisher test.

Questions about successful novelties

The first part covers the decision to start an innovation. Radical innovators are significantly more influenced by research. This result may be connected to their high level of education, accompanied by strong ties with the academic world. However, these are the four default options in the following order of approval on relevant factors to start an innovation: own decision with 54%, market with 31%, single customers with 24% and research with 17% positive answers.

When asked about temporarily involved partners of business or science, a total of 34% answered affirmative, though there were no significant differences, nor were there any in the development time of the innovation to the product, which averaged 4.6 years. Also, intellectual property is of similar importance for both groups: 66% agreed to secure their novelties in this way.

Internal success factors

When examining selected success factors there are no differences in terms of autonomy at work for employees, or the importance of open communication of ideas with the outside world. Both groups attach much attention to internal, cross-departmental communication and 40% include investor capital at times.

The majority of both groups employs specialized staff for research and development, engages in few innovation activities abroad and rarely aborts innovation projects..

Political framework

A comparative analysis of political factors shows that incremental innovators attach a significantly higher importance to digital infrastructure than radical innovations. Individual statements suggest that efficiency and cost reduction play a role here.

In the next section, there were no differences again: exploring new technologies, political support in the context of intellectual property, energy price, reduction in bureaucracy, acceptance of novelties, incentives for employee qualification, as well as reduction in political requirements.

Incremental innovators significantly support reduced taxes and duties, while in turn the availability of real laboratories or funding is not rated any differently.

The question about networks of entrepreneurs resulted in one significant difference: for incremental innovators, networking with experts is significantly more important than for radically innovative respondents. Furthermore, neither technology-based, nor interdisciplinary, regional, cross-industry, international or academic networking is valued any differently.

In the context of the collaboration with research institutions and universities, the following options were not weighted any differently: direct contact with institutes, acquisition of licenses, theses, contract research, internships, consulting, staff exchange, direct cooperation, laboratory work and materials testing. Overall, the companies prefer to maintain direct contact with institutes, with a low interest in the acquisition of licenses.

The perceived interest of research regarding collaboration with businesses as well the satisfaction with this cooperation did not differ significantly.

Decision-making

Finally, the question of including employees in decision-making processes as opposed to sole decisions by the company management was not answered any differently.

Interim conclusion

In total, four of the 50 items produced a significant difference. However, this result fits with the overall picture. The strong connection of radical innovators to science shows up in their willingness to be inspired by research results. The incremental companies take significantly more interest in terms of regulatory requirements such as taxes and duties or digital infrastructure. Furthermore, for this group technology-oriented networking is significantly more important.

This result shows that the closed questions were hardly able to identify specific factors of radical innovators. If summarized, in ascending order: funding, personal networks, a dedicated R&D department, direct access to research institutes, autonomy of work and internal communication are of the greatest importance. In contrast, topics such as licenses, real laboratories or the price of energy are of lesser interest. Since the study aims at the differentiation of innovators, this perspective will not be discussed any further.

For the sake of clarity, the following table is sorted according to the probability of error. Most significant results therefore rank at the top. The second and third column provide the number of innovators with a positive answer.

Fisher Test	N=40	N=30				
Feature	**Radi. Yes**	**Inkr. Yes**	**Chi-Quad.**	**Erroneous.**	**RI > II**	**II > RI**
Trigger research	11	01	7.049	0.007	**	
Digital infrastructure	04	10	5.933	0.017		*
Duties, taxes	03	08	4.755	0.032		*
Technical networking	06	11	4.377	0.035		*
Network: experts	10	14	3.572	0.051		
Network: regional	08	12	3.360	0.059		
Network: overall	17	19	2.979	0.069		
Cooperation	14	16	2.353	0.099		
Network: industry	13	15	2.188	0.109		
Energy price	02	05	2.593	0.114		
Network: non-academic	02	05	2.593	0.114		
Regulatory requirements	05	08	2.275	0.116		
Property rights	03	06	2.391	0.118		
External communication	16	17	1.911	0.127		
Property right	29	17	1.907	0.130		
Disruption	29	17	1,907	0.130		
Dropouts from innovation	23	22	1.872	0.132		
Contract research	15	16	1.742	0.141		
Laboratory and testing	09	11	1.686	0.151		
Decision by management	26	15	1.590	0.155		
Network: international	18	18	1.544	0.158		

Fisher Test	N=40	N=30				
Feature	**Radi. Yes**	**Inkr. Yes**	**Chi-Quad.**	**Erroneous.**	**RI > II**	**II > RI**
Reducing bureaucracy	08	10	1.595	0.162		
Internships	07	09	1.519	0.172		
Own decision	24	14	1.228	0.193		
Acceptance of innovation	03	05	1.423	0.207		
Consultancy	03	05	1.423	0.207		
Real laboratory	02	04	1.519	0.211		
R&D International	10	11	1.111	0.214		
Network: academic	10	11	1.111	0.214		
R&D Department	29	15	1.141	0.219		
Employee qualifications	10	11	0.974	0.234		
Customer initiation	08	09	0.932	0.246		
Kick-off from market	11	11	0.668	0.288		
Student theses	11	11	0.668	0.288		
Autonomy at work	05	06	0.728	0.299		
Venture capital	17	11	0.337	0.370		
Internal communication	39	28	0.726	0.392		
Licenses	03	01	0.552	0.423		
Research institutes	33	26	0.225	0.448		
Personnel exchange	04	04	0.188	0.473		
Free space	36	28	0.243	0.483		
Funding	29	21	0.052	0.513		
Network: personal	29	21	0.052	0.513		
Satisfied with research	27	21	0.050	0.517		
Interest in research	25	19	0.005	0.572		
Qualification incentive	04	03	0.000	0.650		

Overall impressions of the interviewers

The interviewers rated their overall impression following the interviews for aspects that proved to be potentially differentiating between incremental and radical innovators in preliminary research (Nikula, 2020). Most items were taken from socio-cultural characteristics (Hofstede, 2002), as explained in the results.

This assessment was based on two examples and trained intensely until a satisfactory match was achieved. The scale ranges between 0 = not applicable to 10 = applicable to the greatest extent.

Group statistics: 1 = radical, 2 = incremental				**Significance**	**Sig. level**	
Characteristic	Type	N	Mean		RI > II	II > RI
Surprising	1	40	8.40	0.000	***	
	2	30	5.93			
Competition	1	40	4.00	0.251		
	2	30	4.40			
Long-term goals	1	40	7.35	0.068		
	2	30	6.50			
Striving for security	1	40	3.13	0.065		
	2	30	4.03			
Employee satisfaction	1	40	6.08	0.062		
	2	30	7.07			
Economic goals	1	40	6.15	0.182		
	2	30	5.60			
Individualism	1	40	7.50	0.000	***	
	2	30	4.00			

Radical innovators are rated as being more surprising and individualistic than incremental entrepreneurs to a very high degree. Three other characteristics just fall short of significance: radical entrepreneurs put more emphasis on long-term goals, are more willing to take risks and pay less attention to employee satisfaction. Competition as well as economic goals are not any different.

Interim conclusion and cross comparison

Significant differences between the two groups can be found with this methodology. To shore up this finding, a discriminant analysis was calculated, using the interval-scaled items only, i.e., not answered just with yes / no. 15 characteristics may be used: turnover, number of employees, market segment, age, level of education, position, duration of innovation, surprise, competitive orientation, long-term goals, striving for security, employee satisfaction, economic goals and individualism.

Discriminant analysis

Wilks' Lambda	**Chi-square**	**Error probability**	**Significance**
0.457	47.722	0,000	***

The value of Wilks' Lambda provides the remaining variance in the data after the differences between groups are taken out. Similarly, the chi-square tests whether the means of the variables are different in the two groups. A significance level of p = 0.000 allows, with a probability of error at zero, to distinguish the groups. In other words, compared to incremental entrepreneurs, the radical innovators form an independent group and vice versa.

Furthermore, a factor analysis was calculated using the same data to reveal similarities and differences in a methodology to reduce complexity. This procedure extracts relationships between variables from large amounts of data to form components that correlate with many variables. The following table shows the result:

Component matrix factor					
	Factor				
	1	2	3	4	5
Turnover	0.862	-0.197	0.028	0.215	0.081
Employees	0.785	-0.354	0.180	0.199	-0.011
Market segment	0.659	-0.223	0.154	0.243	-0.107
Age	0.390	-0.011	0.528	-0.247	-0.134
Education	0.235	0.194	-0.149	0.619	0.512
Position	0.430	-0.572	0.252	-0.067	-0.216
Duration	0.144	-0.332	0.240	-0.492	0.662
Surprising	-0.041	0.587	0.492	0.325	0.045
Competition	0.588	0.415	-0.320	-0.179	-0.096
Long-term goals	0.257	0.493	0.321	-0.406	0.369
Security	0.587	0.360	-0.463	-0.209	-0.127
Employee satisfaction	0.262	0.189	-0.546	0.040	0.290
Economic goals	0.412	0.716	-0.002	-0.236	-0.246
Individualism	-0.082	0.666	0.479	0.243	-0.027

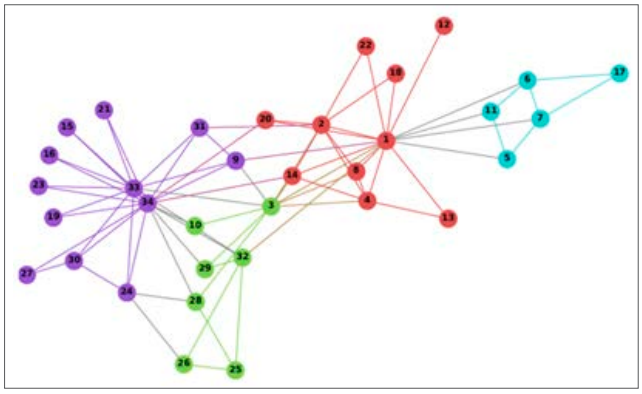
The values in the "Factors" column indicate the degree of correlation between factor and variable, which ranges between -1 and 1. In the first factor and in the order of effect size turnover, number of employees, market segment, competitiveness and the pursuit of economic security form the strongest connections. Entrepreneurs describe these aspects as: achieving the highest possible turnover in competition with other manufacturers to secure the company and its jobs.

The second factor is connected to the pursuit of economic goals, high individualism, the ability to surprise as well as the striving for long-term goals beyond everyday operations. This is obviously a good description of radical innovators as a subgroup of entrepreneurs.

On the basis of the preliminary results, the term "Researching entrepreneurs" is proposed as a name for the radical innovators. On the one hand, this emphasizes the identity as an entrepreneur, furthermore, the high academic qualification and the supply of early market segments by demanding innovators and pioneers, and, last but not least, the ability to do independent research as well as to develop true novelties. The researching entrepreneurs may transform into radical innovators from time to time. However, they do not see their strength in achieving high margins in large series.

Answers to open questions

The previous analysis methods were taken from proven inferential statistics. Based on powerful IT systems, cloud-based storage and artificial intelligence, it is a relatively new option to use free text in order to translate its meaning into structured semantic spaces in the shortest possible time.



Example of the graphical representation of semantical structures.

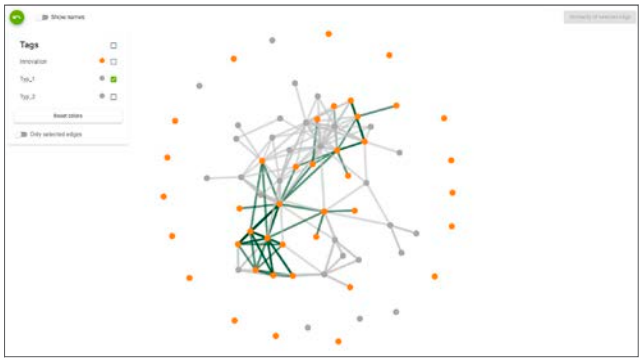
The graphical solution was generated by the content analysis tool "Semantha" of thingsTHINKING from Karlsruhe to group long texts into clusters according to similarities and connections so that content-related comparisons between the sub-structures are possible.

In the following figures, gray lines and nodes represent incrementally innovative entrepreneurs while the different colored lines and dots stand for the radical ones. Isolated points contain incomparable statements.

To examine the statements of the two groups, central statements in a cluster were compared by analyzing their content in a qualitative way.

Questions about successful novelties

The first open question concerns the definition of the term "innovation".



Graphical representation of the answers to the question "How do you define innovation?"

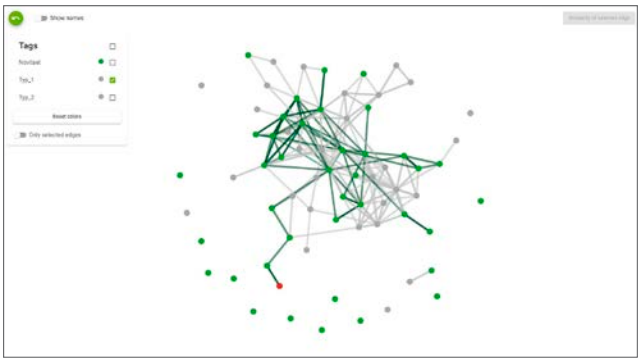
In the core of the upper, gray cluster statements of the incrementals one finds: "New ideas and inventions", "Research turns money into knowledge, economics turns knowledge into money" or "Do something new".

The definitions of radical innovators are grouped differently around statements in the lower cluster: "Successfully placing products on the market", "Groundbreaking innovation" or "Changes the lives of customers". Innovation is put into a context and the claim to be groundbreaking is raised.

Overall, incrementally innovative entrepreneurs tend to reproduce well-known formulations, whereas radical innovators include a market perspective in a more original way.

Conclusion: The concept of innovation is obviously understood in many different ways, which is surprising given the popularity of this word.

The following question asked for a description of the most successful novelty in terms of functionality. This is the picture that emerged:



Graphical representation of the answers to the question: "What is your current or most successful innovation in the past? What is (was) its (planned) functionality?"

Numerous matches are linked at the core of the matrix. In the lower right cluster, typical quotes of incremental innovators are: "New applications of existing materials", "Recovery of electrical energy in the production process", "Integrate a new functionality into an existing system".

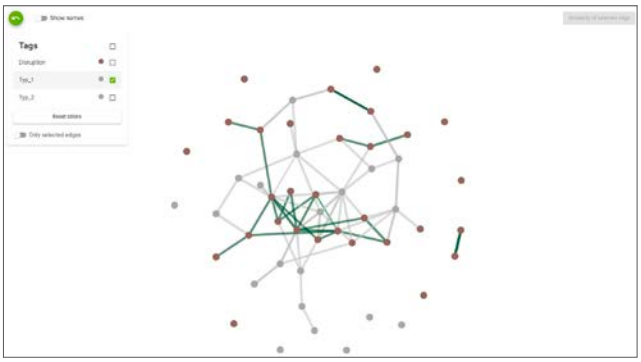
These are statements from the radically innovative entrepreneurs from the upper left cluster: "Autonomous driving", "A much more powerful product", "3D metal printing".

The impression taken from the previous analysis, that radically innovative entrepreneurs generate demanding novelties, is confirmed. This also applies to the tendency of the incremental companies to improve existing things.

Conclusion: Innovation seems to have at least a double function: to improve existing products in order to make them more profitable, or to fulfill new customer needs.

The following question is particularly interesting in the context of this study and concerns the definition of disruption, which 46 of the 70 companies have stated to have elicited. Contrary to expectation, the number of radical innovators did not differ from the number of incremental companies. So, it does not seem to be characteristic of radical innovators to trigger non-linear market transformations.

The semantic space of the two groups looks as follows:



Graphical representation of the answers to the question: "Did one of your innovative products ever elicit a sudden rise in demand? If so: please explain."

The following statements of incremental innovators are found on the right-hand side above the center: "Awards increase demand", "Increasing demand when the new has proven itself", "Complicated approval processes have finally been completed".

Radical innovators express themselves differently in the middle, left cluster: "Be enthusiastic, react quickly to increasing demand, involve customers in the prototype „, "B2C is more disruptive than B2B", "High customer trust, can react quickly".

Incremental innovators emphasize security-related issues, while the radically innovative companies name speed and the relationship with customers as paramount.

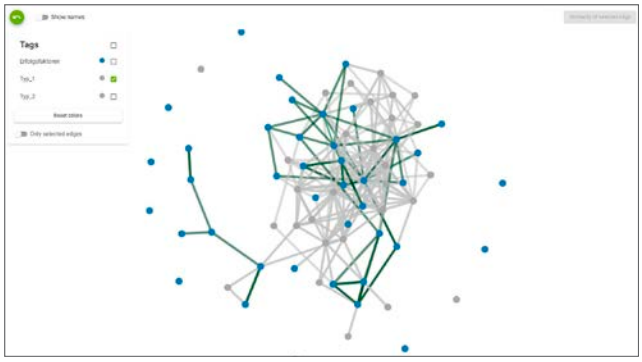
In general, these statements tend to be descriptive, so the self-assessment of the companies should be checked using objective data. Here, parameters have to be recorded that go beyond an interview. The analysis of time series as well as complex market dynamics would prove what can only be sketched out in the present study.

To test this assumption, the companies that indicated a disruption were compared with the others using all available data. There was only one significant difference: the disruptive companies pursue long-term goals more intensively than those who did not indicate disruption.

Conclusion: The self-assessment as disruptive entrepreneur leads to a surprising result: 17 out of 30 (57%) incremental innovators report at least one non-linear rise in demand, as well as 29 of 40 (73%) radically innovative entrepreneurs. For the time being it can be stated that disruption is far more common than expected.

Success factors in the company

Another open question related to success factors in the companies:



Graphical representation of the answers to the question: "What are the three essential success factors for innovation in your company?"

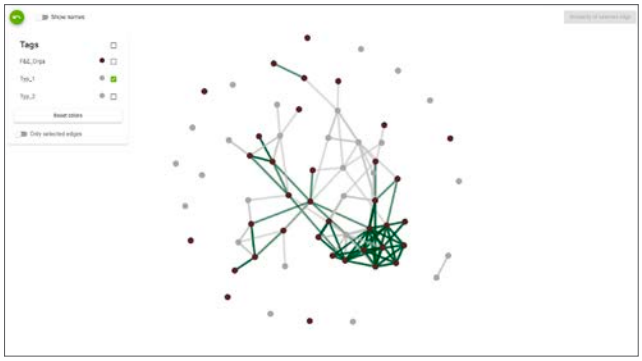
The far greater spread of the incremental entrepreneurs is evident, likewise the agglutination in the central area of the semantic space. The most typical statements are: "Uniqueness, productivity, qualitative Implementation", "Employee qualification, autonomy at work", "Quality, dynamism in the team".

In comparison, these are the statements made by the radical innovators left of center: "Effectiveness, analyzing, evaluating, include sales", "Market experience, creative employees, innovation-related leadership", "Good team, timing, right innovation level for the market".

On the common basis of team-related statements, radical innovators reveal a more pronounced market perspective. Still, there is much common ground that suggests that both groups consist of successful entrepreneurs.

Conclusion: This is a strong hint regarding the importance of a highly qualified and motivated workforce in an effective cooperation.

The next open question relates to the way in which the companies organize research and development in the context of innovation.



Graphical representation of the answers to the question: "Is your company active in the area of research and development with own staff? If so: How is R&D organized in your company?"

The incremental innovators gave the following statements in weakly connected clusters: "Project-related organization", "During the operational business", "Temporary teams, research close to day-to-day business".

The radically innovative companies form a closely connected cluster at the bottom right: "Own department", "Managing director develops himself", "Permanent involvement of every employee".

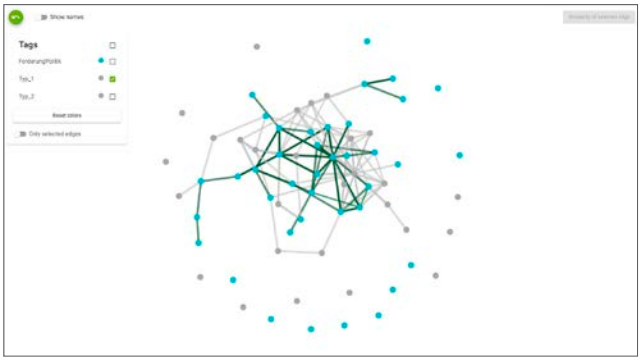
The radically innovative companies are organized differently compared to the incremental colleagues. A specialized department works on R&D, top management is involved personally, and in smaller companies it may be the constant task of every employee to support innovation.

The incremental companies, on the other hand, tend to work on innovation alongside day-to-day business, which – if available – applies to their R&D departments. It should be considered that their number of employees is higher than that of the comparison group.

Conclusion: A profound difference manifests itself between doing innovation parallel to routine work at incremental innovators and focusing on development processes independent of everyday business at radically innovative companies.

Political framework

The following part refers to opinions on the current political framework for economic innovation:



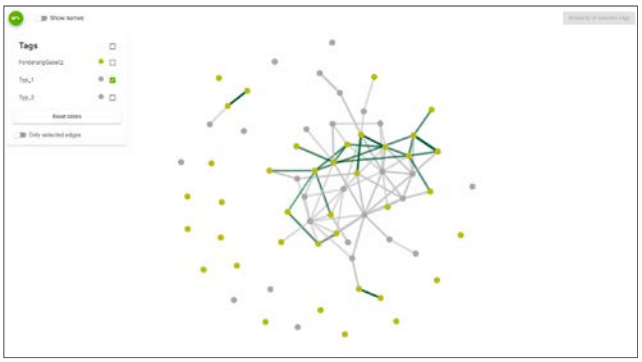
Graphical representation of the answers to the question: "What are the three most important political frameworks for generating innovation from your perspective?"

Here the statements of the incremental respondents largely match those of the radical innovators. In the cluster above the center, three formulations of the evolutionary companies are grouped: "Infrastructure, livable city, venture capital, research projects", "Financing, promoting patents", "Fewer prerequisites, encourage entrepreneurship".

The radical innovators describe the political framework in the central, closely connected cluster: "No majority of opposing people, financial resources, positive basic attitude", "Easier operating permits, more support by city administration", "More technology funding in industrial research".

Conclusion: Demands on politics do not differentiate. It can be assumed that innovators most likely express themselves here as entrepreneurs.

The question of what is desired from the legal framework for innovation aims in a similar direction:



Graphical representation of the answers to the question: "What adaptation or change in the legal framework would help you implement innovation?"

A large number of weakly or un-connected statements occur, with the incremental innovators again spreading out more than the comparison group.

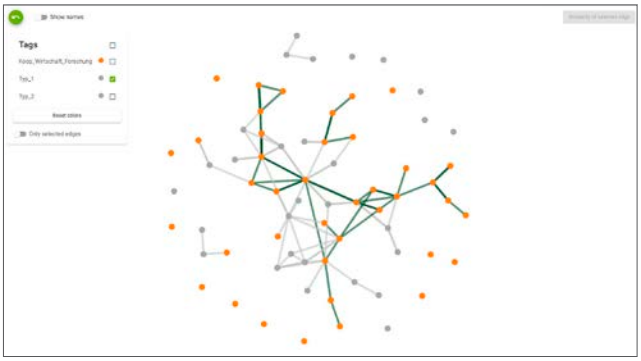
In the central area, a cluster of evolutionary innovators is recognizable: "Support SMEs more than start-ups", "Providing space for innovations", "Affordable collaboration with universities".

In the area above the center, formulations of radical innovators are: "Promote technology, venture capital, reduce dependency on other countries", "Technology related support with funding programs, speed ", "Less regulation, funding from prototype to ready for the market".

Conclusion: This question generates a complex collection of diverse proposals for legislature, again from an entrepreneurial perspective. The radical innovators focus on the promotion of technology, whereas the incremental entrepreneurs seek support in a more unspecific way. A substantial difference between the two groups cannot be identified.

Cooperation with universities and research institutions

The next question relates to the desired cooperation with universities and research institutions. Here, it should be noted that in the overall group, 34 innovators did not involve any partner in the innovation at all, 22 cooperated with other companies, 8 with a university and 6 with a research facility. In this aspect, there is no difference to be found between incrementally and radically innovative companies. The answers can be visualized as follows:



Graphical representation of the answers to the question: "What would be the optimal cooperation with universities / research institutions from your perspective?"

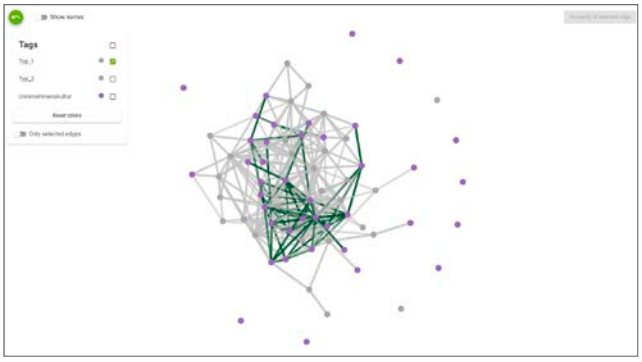
Again, many statements are isolated or weakly connected and do not show significant differences between the groups. Central statements of the incremental innovators are: "ZIM program is a model", "Cooperation without hurdles", "Direct exchange".

The radical innovators name the points: "Clarity in relation to the IP", "Factual, quick", "Partnership, financing should serve the project".

Conclusion: Both groups agree that they would prefer a direct, partnership-based exchange with research. The ZIM program was designed with this in mind and is mentioned in several interviews as a positive example.

Corporate culture

Finally, the question was to point out characteristics of the corporate culture in general without referring to innovation:



Graphical representation of the responses to the question: "Describe the three most important features of your corporate culture."

Again, with numerous unrelated statements, the matrix reveals the embedding of the statements of the radical innovators in an overall system of the widely dispersed remarks of the incremental company.

Typical examples of evolutionary innovators are: "Employee potential is to be developed", "Decisions taken in the team, fairness", "Openness, security, togetherness".

The radical entrepreneurs in the cluster below the middle point out: "Open communication, flexible organization", "Open to new things", "Transparency, flat hierarchy, communication".

Conclusion: On a common basis of close, trusting cooperation radical innovators place slightly more weight on openness, communication and dynamic organization. Still, these points have to be regarded as similar. It is assumed, that the identity of a successful entrepreneur has a stronger impact at this point than the different orientations towards gradual or radical innovation.

As a result, this methodology reveals many similarities, corresponding with the fact that both groups include successful entrepreneurs. Differences arise in regard to the distinct organization of R&D and the involvement of management at radical innovators, while incremental companies tend to innovate alongside everyday business.

Recommendations

The following recommendations are based on the statements of the respondents and the results of the study.

Recommendations for politics

Numerous theses were formulated on this topic:

- "Politics in our country are well structured, fast, can take action sometimes, give planning security and are reliable."
- "Political support is of particular importance, especially in the early phases of innovation."
- "Politicians should stay out of the way, help only to a limited extent, less intervention."
- "Politics must enable innovation, not prevent it. The provisional traffic approval for novel mobility concepts is hardly possible."

In general, political actors are considered reliable partners whose support can be decisive in the pre-competitive area, so that risky innovation can actually take place. Political support should be targeted and limited in time.

It is important that the discourse between researching entrepreneurs and political partners is intensified to pursue the shared objective of a highly innovative economy. It should be noted that proven tools to support incremental innovators are not automatically transferable to researching entrepreneurs.

In order to support disruption, it should be considered how to apply existing funding programs to enable disruptive innovation. This might also mean to configure or change a future-oriented funding program, in addition or connected to SPRIND, to focus on the special needs of researching companies. On the other hand, it is suggested for the responsible ministries to establish communication with radical innovators on a regular basis. Finally, high-profile events will lead to a discourse of researching companies and political partners.

Recommendations for the Agency for Disruptive Innovation SPRIND

SPRIND is ramping up and was unknown to many innovators. In some cases, it is generally recommended:

- „Enable innovation in freedom and develop complex solutions."
- "This agency could build a database of solutions."

At present there are five ongoing projects:

- Micro flotation to solve the microplastic problem.
- High-altitude wind turbines for generating energy.
- Analog computers to enable parallel working processors.
- Artificial intelligence to simulate processing of the human brain.
- European cloud infrastructure based on open source.

Researching entrepreneurs can contribute in this context by taking part in competitions or submitting suggestions. In addition, it is recommended to use the expertise of radical innovators in more specific ways like examining potentially disruptive novelties or sharing experiences with dynamic markets. Furthermore, it is proposed to establish an entrepreneurial advisory board – in addition to the supervisory board – and to create effective publicity formats such as podcasts or public events including researching entrepreneurs.

The study also made clear that disruption occurs much more frequently in specialized sub-markets than originally assumed. This offers an opportunity to track and analyze disruption while it happens.

Recommendations for research institutions and universities

Scientific work is a basic capability of researching entrepreneurs. Hence their requirements for the academic world are quite specific:

- "A healthy dualism of scientists and entrepreneurs."
- "The entrepreneurs should set the pace of the projects."
- "Improve framework conditions for spin-offs."

Scientific institutions have a wide range of tools at their disposal, such as contract research or other forms of cooperation with entrepreneurs. They are also potential customers of innovators. There should be a discourse between the academic world and entrepreneurs to design cooperation in the context of disruption. Radical innovators have stated that instead of a receiving role in the transfer of knowledge and technology they prefer active cooperation.

Furthermore, the entrepreneurial competence of spin-offs should not only be strengthened by academic qualification but also include researching entrepreneurs as mentors. Examples of this approach are known from innovation hubs.

Recommendations for incrementally innovative entrepreneurs

To try out the path to radical novelty, a first model test is recommended. It is helpful to stay in contact with radical innovators for this purpose.

Furthermore, research supports spin-offs, which may open up cooperative possibilities for incremental innovators. To accept study and doctoral theses, offers opportunities both for personnel acquisition and contact with science. In addition, research institutions provide contact points for innovators through the technology transfer offices.

Both for incrementally innovative entrepreneurs and radical innovators, real laboratories or innovation cluster may be useful to install and improve cooperation with research or to test novelties under controlled conditions. Finally, the ZIM program is well accepted for these purposes.

Recommendations for researching entrepreneurs

Many researching entrepreneurs do not seek growth and reject series production. This is explained by worries about losing contact with the workforce from a certain company size on and being preoccupied with administrative tasks.

However, examples are known in which mass production is operated in a separate, new division. By out-licensing novelties, on the other hand, the opportunity for growth of the own company is lost.

It is therefore recommended for radical innovators to create models to unite the seemingly incompatible: creative innovation at the core of the company and an affiliated series production.

As a final impulse: actors involved in disruption, especially researching entrepreneurs should share their experiences. Both SPRIND as well as the IHK landscape, including the DIHK, are able to offer a forum for this purpose..

Recommendations for investors and funds

Researching entrepreneurs surprisingly often finance their innovations from their own cash-flow to maintain independence.

The highly structured processes of funds and investors, on the other hand, provide financial resources in a considerable amount. Therefore, numerous innovators have expressed specific statements based on personal experiences:

- "Investors have to believe in the company and sustain long development periods."
- "Foreign investors buy innovators and move them to emigrate."
- "More venture capital is needed for young companies."

However, the peculiarities of radical innovation show up, when entrepreneurs cannot provide justifiable forecasts in the early stages of development, contrary to incremental innovators. At this point, the willingness to take financial risks is less pronounced in Germany as compared to the USA, China or Israel (cf. Luke, 2020).

Funds such as the German High-Tech Gründerfonds are supposed to address this imbalance, though for researching entrepreneurs this system is not available. Therefore, it is often the case that investors from the above-mentioned nations finance German innovators and convince them to relocate. Global competition includes support for start-ups and established innovative companies as well. A reconsideration of funding towards radical and disruptive innovation may be needed.

Recommendations for media and society

The professional world appreciates the contributions of creative companies. Researching entrepreneurs, however, express their wish for greater social recognition, occasionally in the spirit of Prince Philip, who proposed to celebrate innovators like pop stars, which may apply to the Tesla CEO, for instance. The vast majority of innovators do not seek public awareness of this kind. Still, their performance should be recognized more.

Here are some quotes:

- "The media presence oscillates, for instance following an award ceremony, after that it subsides again."
- "We are only reported about when there is a fire."

However, the future potential of innovators is high. Radical novelties can turn into successful mass products. To neglect this part of the national economic system puts the capability at stake to play an important role in the future.

To resolve this contradiction, it is recommended to enhance public awareness of radical novelties and disruption. Existing formats in established media or periodicals can cover more of the activities of researching entrepreneurs. In a similar way, YouTube channels can reach large audiences to create awareness for the achievements of innovators. The same applies to popular science publications and award ceremonies. However, it is recommended that the juries do not wait passively for submissions but rather contact researching entrepreneurs. More public communication strengthens the understanding of new technologies.

Recommendations for the Chambers of Industry and Commerce (IHKs)

The IHKs are often mentioned by innovators:

- "First point of contact for innovators also."
- "Support with regard to regulatory requirements."
- "The IHKs know the funding opportunities for innovators."
- "The basis for development teams are networks created by IHKs."

IHKs are seen as reliably accessible contacts for their members including the hosting of committees, working groups and events. They also offer expertise regarding the regulatory framework and the complex landscape of funding instruments. Here, the IHK innovation consultants play a key role.

The IHKs and researching entrepreneurs should develop concepts to support radical and disruptive innovation that are as new as the novelties of the companies. These may relate to the following topics: access to early market segments, acceleration of development cycles, application of artificial intelligence etc.

In this context, the particular strengths of the IHK are: market knowledge, including that of latent needs, and the assessment of the potentials of both existing and technologies yet to be created. The IHKs represent not only industry but also market players, whose crucial role in disruption was outlined in the present study.

Furthermore, the IHKs and the DIHK should examine how their innovation consultants could actively support the Agency for Disruptive Innovation in their search for suitable projects and the rollout of results.

Recommendations for the Association of German Chambers of Commerce and Industry (DIHK)

The DIHK supports the cooperation of IHKs on a regular basis, represents the interests of German economy both at the federal and the EU level, and coordinates the work of the German Chambers of Commerce Abroad aka AHKs. This organization was involved in the concept and foundation of the Agency for Disruptive Innovation and continuously supports its work. Hence, the present study was commissioned and there is a great willingness to support the future development of this issue.

Radical and disruptive innovation is also a nationwide topic for which the DIHK is predestined. The efficient networking of this organization makes it possible to bring together experts from different areas. Innovators find a platform to gain access to markets and technologies but also to promote awareness for innovators. This includes not only technical experts but also politics and the general public.

It is therefore recommended to install a specialized contact point for researching innovators. Knowledge can be accumulated and made available to the IHKs and AHKs as well as companies. This would improve the ability to generate impact on politics, science and the Agency for Disruptive Innovation. The ability of a society to be radically innovative and disruptive needs all the complex and systematic support it can get, with the DIHK in the frontline.

Summary and integration of the results

Inspired by the foundation of the Agency for Disruptive Innovation, the intention arose to find and characterize radical innovators in the German economy. Originally, it was expected that these companies are also disruptively innovative, which has not been confirmed.[2]

The percentage of entrepreneurs who are able to place a radically new technology in new markets may be regarded as small.[3]

There is no compelling reason to generate an incessant stream of radical novelties as the markets for fundamentally new products are limited. Pioneering customers must be willing to pay a high price. Still, this small group stands out by a considerable commitment to obtain radically new things and also by sufficient financial resources. In many cases this segment consists of entrepreneurs.

Nevertheless, from an economic point of view, radically innovative companies take on an indispensable role. They generate new technology, which is further improved by either themselves or incremental innovators to become mass products. And in many cases, they pick up on research results, as Prof. Hell pointed out in the foreword.

Investors may support radical innovation well before the transition to the mass market as they may create a very much higher margin than incremental innovators. Funds are also active in this phase that offer high risk projects a chance that can hardly be financed through the normal channels.

Researching entrepreneurs work scientifically and run their own laboratories and workshops. They maintain constant contact with the academic world to absorb impulses from research and are often invited for presentations.

This group confirms the excellent performance of universities and research institutions in Germany, where future radical innovators learn how to work in a scientific manner.

The companies of researching entrepreneurs are rather small. In accordance with this observation, large companies tend to form small units for innovation, in part to be placed far away from the headquarters.[4]

[2] It may be assumed that the vast majority of companies manufactures series products, skim off profits, and thus secure jobs. Many of these employers are estimated to be innovative in their self-assessment, as numerous studies have shown. Hence, the present study focuses exclusively on products recognized by the market as clearly progressive or a radical novelty, not on processual, organizational or any other form of innovation.

[3] This is confirmed by the fact that an intensive search for radically innovative companies, starting from a basic stock, relatively quickly led to 80 examples, to which fewer and fewer were added over the course of time. At the end of the process, only such companies were mentioned that were already known. It is worth remembering that a total of 161 highly innovative companies were found.

[4] This describes the origin of "Open spaces" at Telekom, which included customers in a "Think tank". Especially in Berlin, companies have founded many innovation labs. Of the 34 known hubs (Projekt Zukunft Berlin, 2018), special mention should be made of Porsche, Pfizer and Henkel. The intention is to generate the dynamics of start-ups rather than to follow the rules of procedure in large companies.

Referring to the personal characteristics of researching entrepreneurs, the ability to surprise, while curiosity-driven, emerged in the interviews. While incremental innovators improve existing products, researching entrepreneurs are able to think about completely new products.

The second strong personal trait is individualism, understood as the desire to be unique, while in collectivism the individual strives to belong to groups.[5]

In many international comparisons the USA, UK and Australia are regarded as highly individualistic nations where the uniqueness of radical innovators is accepted. This can also be found within DARPA, where individual program managers play a vital role.

At the beginning of its creation, the radical novelty can be described as something completely new and unique. It is therefore just as individualistic as the researching entrepreneur.

An insightful perspective is offered by the long-term goal pursuit approach (Klinger, 1978; Kuhl, 1981), which deals with the question of how the long-term pursuit of complex goals can be explained. How can complex goals be pursued over many years? The concern to generate a radical novelty requires perseverance. Non-individualistic entrepreneurs are more likely to be exposed to the influences of critics than innovators who follow their own journeys.

Individualism is therefore much more than just a personality trait or a sociocultural phenomenon. Rather, it explains the long-term commitment of researching entrepreneurs, in addition to everyday business and partly against objections by the environment as well as undeterred by failure to develop a radical novelty. The achieved breakthrough of the radical novelty compensates for all troubles. However, there should also be a willingness to give up hopeless projects, as von Helmholtz (1896) pointed out.

Looking at it from another angle, the question may be raised whether radical technological novelties cause disruptive innovation in the sense of a non-linear market transformation by some kind of automatism? 46 out of 70 innovators reported to have experienced a non-linear rise in demand. This seems to be a common phenomenon and rather than a rare exception.

However, the markets of those companies should be analyzed. 24 innovators produce an end product but do not supply the mass market. Rather, they are connected to highly specialized, small markets within industry, which operate largely outside public attention. The same goes for the remaining 22 manufacturers and their B2B products.

If a new type of cleaning system using micro flotation is installed at sewage treatment plants, the demand of the community of municipal utilities increases sharply with a few dozen orders, which will not create any public interest. Still, this is disruption when a newcomer takes away market shares from traditional filtration companies. In summary, it can be stated that in the B2B area, especially the machinery market, disruptive reactions in the sense of exponentially increasing demand, are more the rule than the exception. In these highly specialized, closely related networks, a quiet kind of disruption takes place, which goes unnoticed by the general public.

Another question is whether radical novelties elicit a rising demand immediately? It may be postulated, that there are the most responses when latent market needs are fulfilled. The appropriate products may be innovative or originally established for other purposes, like the mp3 algorithm, which was developed for unspecific data compression, not for music. The following quote was heard during a conference (Gassmann, 2012, personal communication): "The OEM ... tries to develop products that the customers did not know they were looking for but which they find thrilling when they have it. This only works if latent needs are addressed intelligently."

Several innovators have suggested that the willingness to accept new products is greatest during periods of imbalance. Market entry will usually take place via niches. Last but not least, a saturated market is not very receptive for new things.

Niche markets however are, due to longstanding cooperation of customers and producers, generally more stable but, at the same time, more receptive for novelties. Disruptive innovation thus results from an interaction between companies and market forces, not as a linear reaction to the market entry of radical novelties.

The suggestions of the DIHK Innovation Report (v. Bredow & Hüwels, 2020) are relevant in this context. Networking plays a crucial role in modern markets. These systems are digitized, characterized by a high speed of information exchange and expect a high agility from innovators. Production must be ready to respond fast and with increased capacity to a rising demand. Just in this interconnected case, disruptive innovation takes place in the true sense of the word.[6]

[5] If this motive is viewed from the socio-cultural perspective (Hofstede, 2010), six dimensions emerge by which socio-cultural systems and individuals can be distinguished: power distance as a broad versus narrow distribution of influence, individualism versus collectivism, masculinity versus femininity, avoiding versus accepting uncertainty, long-term versus short-term goals, enjoying versus reluctance.

[6] An automotive supplier mentioned this aspect. His company was asked to design their production in such a flexible way that a dynamically increasing demand could be served.

Outlook

After the type of "researching entrepreneur" has been found and sketched, it is a logical step to understand the dynamics of disruptive innovation in the markets. The surveyed companies can offer an empirical basis for this purpose. The customers and markets of the 46 "disruptors" are examples to pursue ongoing disruptive innovation.

In terms of methodology, it has proven effective to use a tool based on artificial intelligence. If it were possible to distinguish successful from failing novelties in a similar way, it would be easier to plan innovation.

To utilize the statements of innovators, competitiveness is a decisive factor to prosper in the future. National innovation agencies are globally active, which also applies to scouts who work on behalf of investor groups. Hence, in the networked age, the disruptive potential of novelties or latent market needs are recognized far earlier than a few years ago. The competitiveness of an economy therefore partly depends on researching entrepreneurs whose importance should be valued highly. Science has demonstrated the ability to attract top performers as well as to keep them in the country. Researching entrepreneurs are top performers as well and politics should be aware of that.

Another factor is not only the acceptance of new technologies in advanced market, but also in society. Public agenda is often directed towards large companies with significant workforces in series production. Their total share in the gross national product, however, is essentially smaller than that of small and medium-sized enterprises. Novelties and thereby future series products are created more often by SMEs than by large companies, though the latter´s advertising may suggest differently.

Accelerating development and life cycles are mentioned by many innovators, so that innovation, even the most radical, is a permanent task. The necessary qualification places considerable demands on the development of new skills of the employees in a time that is shaped less by presence than by digitized learning.

The Covid-19 pandemic was mentioned many times. Some entrepreneurs formulated the goal of building a second, automated production layer to be able to maintain productivity in times of expected lockdowns at the highest possible level with a minimum number of employees. It is to be expected that this disruption may change production systems fundamentally.

A society able to produce and absorb radical novelties with disruptive potential will be able to master the balance between constant improvement and transition, and thereby master the future.

Participants

_blaenk GmbH, Köln

Abberior GmbH, Göttingen

AEM-Anhaltische Elektromotorenwerk Dessau GmbH, Dessau-Roßlau

AKmira optronics GmbH i.G., Potsdam

altona Diagnostics GmbH, Hamburg

apeiron restaurant & retail management gmbh, Bonn

B.R.A.I.N. Biotechnology Research and Information Network AG, Zwingenberg

Berlin Heart GmbH, Berlin

BPW Bergische Achsen Kommanditgesellschaft, Wiehl

Brose Fahrzeugteile SE & Co. KG, Coburg

Desma Schuhmaschinen GmbH, Achim

Digatron Power Electronics GmbH, Aachen

doks. Innovation GmbH, Kassel

e.GO MOOVE GmbH, Aachen

Efficient Energy GmbH, Feldkirchen

enviplan® Ingenieurgesellschaft mbH, Lichtenau-Henglarn

EOS GmbH Electro Optical Systems, Krailling

ERLAS, Erlanger Lasertechnik GmbH, Erlangen

Eurabus GmbH, Berlin

Eurofoam Deutschland GmbH, Troisdorf

FEHRMANN GmbH, Hamburg

Filter Profitlich Maschinenbau GmbH, Bad Honnef

FlexLink Systems GmbH, Offenbach am Main

Flussstrom Energy GmbH, Magdeburg

FRERICHS GLAS GMBH, Verden (Aller)

Geiger Engineering GmbH, Hirschaid

geotechnik heiligenstadt gmbh, Heilbad Heiligenstadt

German Tech GmbH, Hamburg

in.hub GmbH, Chemnitz

IndiKar Individual Karosseriebau GmbH, Wilkau-Haßlau

KARL STORZ SE & Co. KG, Tuttlingen

Kastner AG, Wolnzach

Kotte Landtechnik GmbH & Co. KG, Rieste

LAMILUX Heinrich Strunz Holding GmbH & Co. KG, Rehau

Lux-Werft und Schifffahrt GmbH, Niederkassel

m2m Germany GmbH, Wehrheim

Magnetfabrik Bonn GmbH, Bonn

MinebeaMitsumi Technology Center Europe GmbH, Villingen-Schwenningen

MK Technology GmbH, Grafschaft

myPOLS Biotec GmbH, Konstanz

NanoWired GmbH, Gernsheim

OSWALD Elektromotoren GmbH, Miltenberg

OSYPKA AG, Rheinfelden

PETER BREHM GmbH, Weisendorf

Print2Taste GmbH, Freising

RASTAL GmbH & Co. KG, Höhr-Grenzhausen

regyonal - GAL Digital GmbH, Hungen

Reifenhäuser GmbH & Co. KG Maschinenfabrik, Troisdorf

Rhebo GmbH, Leipzig

RITTEC Umwelttechnik GmbH, Lüneburg

Schaeffler AG, Herzogenaurach

Schönborner Armaturen GmbH, Doberlug-Kirchhain

Schunk Ingenieurkeramik GmbH, Willich

Spreitzer GmbH & Co. KG, Gosheim

STABL Energy GmbH, München

Syrphus GmbH, Seevetal

tacterion GmbH, München

TAMSEN MARITIM GmbH, Rostock

Theion UG (haftungsbeschränkt), Berlin

thingsTHINKING GmbH, Karlsruhe

thyssenkrupp Elevator Innovation and Operations GmbH, Rottweil

TI.KI Technologisches Institut für angewandte Künstliche Intelligenz GmbH, Weiden

Trionplas Technologies GmbH, Leipzig

unu GmbH, Berlin

Urban Cargo FMRP UG (haftungsbeschränkt), Berlin

Voith GmbH, Heidenheim

Volucap GmbH, Potsdam

Werner Achilles GmbH & Co. KG, Celle

Wiha Werkzeuge GmbH, Schonach

WIKUS-Sägenfabrik Wilhelm H. Kullmann GmbH & Co. KG, Spangenberg

WILHELM KNEITZ Solutions in Textile GmbH, Hof

ZIGPOS GmbH, Dresden

(2 of those for training purposes)

Questions in the study "Innovators in Germany"

1) Company and innovator characteristics

General questions about the company, number of employees, sector, etc.

2) Questions about the (latest) novelty

▶ How do you define innovation?

▶ What is your current or most successful innovation? What is its (planned) functionality?

▶ What was the impetus for developing the innovation?
☐ Market ☐ customer ☐ research institution ☐ own decision ☐ other

▶ Are there any partners involved temporarily? ☐ Yes ☐ No
If yes, which? (company, scientist).

▶ Are there any competitors for this innovation? ☐ Yes, many ☐ Yes, few ☐ No

▶ Has market entry been achieved? ☐ Yes ☐ No
If so, how much time has passed since the innovation began?

If not, what is the current status? Proof of concept / feasibility, prototype or producibility and how much time has passed since the start of innovation?

▶ Do you have an intellectual property right of your invention? ☐ Yes ☐ No ☐ other

▶ Was there a sudden surge in demand for one of your innovative products? ☐ Yes ☐ No
If so, please explain: Which functionality? Which market? Triggered by what?
Has there been increased demand by customers? Have competitors lost market share as a result?

Questions in the study "Innovators in Germany"

3) Success factors inside the company

- What are the three essential success factors for innovation inside your company and why?

- Autonomy at work: How important is freedom to experiment for your innovation?
  ☐ necessary ☐ not that relevant

- Open Innovation: What is the significance of open communication of ideas with the outside world?
  ☐ necessary ☐ not that relevant

- Interdisciplinary exchange: How important is the internal, cross-departmental exchange for innovation in your company?
  ☐ necessary ☐ not that relevant

- Venture capital: How important is the acquisition of investment in high-risk projects in your company?
  ☐ necessary ☐ not that relevant

- Is your company active in research and development with its own staff? ☐ Yes ☐ No
  If so: How is research and development organized in your company?

- Does your company conduct research and development in other countries? ☐ Yes ☐ No
  If yes, why?

- Have you cancelled any innovation projects? ☐ Yes ☐ No
  If yes, why?

4) Political framework (outside the company)

- What are the three most important political frameworks for generating innovation?

- What adaptation / change in the legal framework would help to implement innovation?

Questions in the study "Innovators in Germany"

▶ Which public funding programs do you use when implementing innovation?

▶ What kind of network will help you generate innovation?
☐ Personal ☐ within the industry ☐ across industries ☐ regionally ☐ supraregional ☐ nationwide experts
☐ others

5) Framework of research

▶ What would be the optimal cooperation with universities / research institutions for your innovation?

A) Have you cooperated with a university or non-university research institution in the past three years?
☐ Yes ☐ No
If not: Is there a specific reason for this?

If so: What kind of cooperation? ☐ Acquisition of license ☐ theses ☐ contract research ☐ internships
☐ consultancy ☐ exchange of employees ☐ cooperation projects ☐ laboratory services, test benches
☐ collaboration in technology networks and clusters ☐ others

If so: Did you get the feeling that the research institution was interested in your specific innovation?
☐ Yes ☐ No ☐ others

If yes: Were you satisfied with the results of this cooperation? ☐ Yes ☐ No
If not: Why not?

B) Are your questions concerning innovation taken up by research institutions and if so: how?
☐ Yes ☐ No

6) Corporate culture

▶ Describe the three most important points of your corporate culture.

▶ Is leadership in your company distributed among few people or are decisions made in a team?
☐ Few people ☐ team

Literature

Beck, R., Beimborn, D., Weitzel, T. & König, W. (2008). Network effects as drivers of individual technology adoption: Analyzing adoption and diffusion of mobile communication services. Information Systems Frontiers volume 10, pages 415–429.

Berkemeyer, N & Junker, R. (2013). Vernetzung als Medium schulischer Innovation. Jena: Friedrich-Schiller-Universität.

Bloomberg Index (2020). www.bloomberg.com.

BMBF (2018). Agentur zur Förderung von Sprunginnovationen. Berlin: BMBF.

Bredow, F. v. & Hüwels, H. (2020). Zeit für Innovation. DIHK-Innovationsreport 2020. Berlin: DIHK.

Cabinet Office (2020). Moonshot Research and Development Program. Tokyo: Cabinet Office.

Christensen, C.M. (1997). The innovator´s dilemma. Boston Mass.: Harvard Business School Press.

DARPA (2020). Defense-Wide Justification Book. Arlington County: DARPA.

Dubois, L.H. (2003). DARPA's Approach to Innovation and Its Reflection in Industry. In: National Research Council, Reducing the Time from Basic Research to Innovation in the Chemical Sciences: A Workshop Report to the Chemical Sciences Roundtable. Washington (DC): National Academies Press, 37-48.

European Innovation Council (2019): https://ec.europa.eu/research/eic/index.cfm.

Fagerberg, J. (2006). Innovation. A guide to the literature. In: Fagerberg, J., Mowery, D.C. & Nelson, R.R., Oxford Handbook of Innovation. Oxford: University Press, 1-26.

Harhoff, D. (1998). R&D and Productivity in German Manufacturing Firms. Economics of Innovation and New Technology, 1998, vol. 6, issue 1, 29-50.

Harhoff, D. & Suyer, A. (2018). Von klassischer Forschungs- zu moderner Innovationspolitik in: Stefan Mair, Dirk Messner, Lutz Meyer (Hg.), Deutschland und die Welt 2030: Was sich verändert und wie wir handeln müssen 263-270. Berlin: Econ Verlag.

Harhoff, D., Kagermann, H. & Stratmann, M. (2018). Impulse für Sprunginnovationen in Deutschland. München: Herbert Utz Verlag.

Helmholtz, H. v. (1896). Vorträge und Reden, erster Band. Braunschweig: Vieweg.

Hippel, E. v. (2005). Democratizing innovation. Cambridge Mass.: MIT Press.

Hölzl, K., Tiberius, V. & Surrey H. (Hrsg., 2020). Perspektiven des Entrepreneurships: Unternehmerische Konzepte zwischen Theorie und Praxis. Stuttgart: Schäffer-Poeschel.

Kaldewey, D. (2011). Das lineare Innovationsmodell als Erzählung über die Einheit der Wissenschaft. Berlin: GWTF & GWG.

Lukas, W.-D. (2020). Kann der Staat Disruption? Berlin: DIHK-Vortrag.

Max-Planck-Innovation (2019). Jahrbuch. München: Max-Planck-Innovation.

Moore, G.C. & Benbasat, I. (1991). Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation. Information Systems Research, 1991, vol. 2, issue 3, 192-222.

Müller, T. & Schroiff, H.-W. (2020). "Warum Produkte und Start-Ups floppen". München: Haufe Verlag.

Nikula, R., Alo, C. Bach, J, Hodzic, S., Jordanidis, A., Keuthen, N., Kohlenbach, L., Peters, M., Sandler, A., Sen, E. (2020). Zur Kommunikation von inkrementellen und radikalen Innovatoren in YouTube-Videos. Sankt-Augustin: Hochschule Bonn-Rhein-Sieg.

Nordfors, D. (2003). The concept of innovation journalism. Stockholm: VINNOVA.

OECD and EUROSTAT (2018). Oslo Manual. Paris: OECD.

Prigogine, I. (1962). Non-Equilibrium Statistical Mechanics. New York: Interscience Publishers.

Projekt Zukunft Berlin (2020). Website.

Rogers, E. (2003). The Diffusion of Innovations. New York: Simon & Schuster.

Rothaermel, F. (2012). Strategic Management. ew York: McGraw Hill.

Schimpf, S. (2020). Praxisstudie Disruption. Stuttgart: Fraunhofer-Verbund Innovationsforschung.

Schumpeter, J. (1947). The Creative Response in Economic History. The Journal of Economic History, Vol. 7, No. 2, 149-159.

SPSS 26 (2019). Dokumentation. Armonk NY: IBM.

Wagner, U, Wimmer, P. & Zipperle, T. (2018). Sektorsteckbrief Gewerbe, Handel, Dienstleistungen (GHD). München: Technische Universität München.

Zerfass, A. & Möslein, K.M. (Hrsg., 2009). Kommunikation als Erfolgsfaktor im Innovationsmanagement. Heidelberg: Springer.