An investigation into the achievement
of critical mass in digital agricultural startups based
on an analysis of German farm management startups

Dissertation
to obtain the Ph. D. degree
in the International Ph. D. Program for Agricultural Sciences in Goettingen (IPAG)
at the Faculty of Agricultural Sciences,
Georg-August-University Göttingen, Germany

presented by

Anna Iversen (born Gubanova)

born in Moscow

Göttingen, December 2018

D7

1. Name of supervisor: Prof. Dr. Ludwig Theuvsen

2. Name of co-supervisor: Prof. Dr. Michael Clasen

Date of dissertation: 13 December 2018

Firstly, I would like to express my sincere gratitude to my advisors Prof. Michael Clasen and Prof. Ludwig Theuvsen. Prof. Clasen supported my Ph.D study and related research. His guidance helped me throughout the research and writing of this dissertation. I would like to thank Prof. Theuvsen, not only for his insightful comments and encouragement, but also for the hard questions with which he gave me the incentive to expand my research from various perspectives. I could not have imagined having better advisors and mentors for my Ph.D study.

Last but not least, I would like to thank my family and friends for supporting me spiritually throughout the writing of this dissertation and my life in general.

Overview

List of tables

List of figures

Abbreviations

API	Application Programming Interface
CABI	Centre for Agriculture and Bioscience International
CEMA	Association for European Agricultural Machinery
DOI	Diffusion of Innovation
EIP-AGRI	European Innovation Partnership for Agriculture
FAO	Food and Agriculture Organization of the United Nations
FMIS	Farm Management Information System
GIZ	German Corporation for International Cooperation
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and Communication Technology
IT	Information Technology
LDA	Latent Dirichlet Allocation
LDAvis	Latent Dirichlet Allocation Visualized
LED	Light Emitting Diode
NASA	National Aeronautics and Space Administration
NGO	Non Governmental Organization
NSAF	Nepal Seed and Fertilizer
QFD	Quality Function Deployment
SO	Standard Output
TAM	Technology Acceptance Model
TLC	Technology Life Cycle
TPB	Theory of Planned Behavior
TRA	Theory of Reasoned Action
TRL	Technology Readiness Level
UTAUT	Unified Theory of Acceptance and Use of Technology
Wi-Fi	Wireless Fidelity
WSA	World Summit Award

1 Introduction

1.1 Problem statement

According to the 2009 report published by the Food and Agriculture Organization (FAO) of the United Nations, due to population growth, food production must increase by 70% by 2050 to meet rising demand (FAO, 2009). To achieve this aim, new technologies are needed. The main source of new technologies is innovation. The main creative power behind innovation is entrepreneurship. Schumpeter was one of the first economists to introduce the entrepreneur as the one who reforms and even revolutionizes the existing production patterns (Schumpeter, 1947). The role of entrepreneurs in the economy is to break old sets and create new ones. To do so, they use the innovation defined by Schumpeter himself as “creative destruction”. In the age of information, entrepreneurial entities are called startups. Startups disrupt the current economic order and bring products to the market that encourage new ways of working and production.

Although innovation often brings new opportunities and benefits, it is not always recognized and accepted by the target group. In the field of agriculture farmers are beginning to realize the necessity to change current practices, especially since changes in price regulations and subsidy policies do not always guarantee a stable income, and climate change also influences the amount of harvest (Dedieu *et al.*, 2009). Nevertheless, the diffusion pace of the new digital agricultural solutions among farmers is not as rapid as expected (EIP-AGRI, 2015). According to the Kondratiev waves, an innovation cycle from developing a new technology to its complete adoption can take 40 to 60 years (Grinin *et al.*, 2016). A historical example in the field of agriculture that might support this assumption is the implementation of new practices and technologies, such as new ploughing methods or breeding selection. These and further innovations were the basis of an English agricultural revolution that started in the middle of the 17th century and reached its peak in the 18th century (Mingay, 1963).

Today the pace of innovation adoption plays a critical role when considering the growing demand for efficient and healthy food production. Two parties are responsible for the pace of innovation adoption: the users of the innovation and the innovators, although the user is the one who decides to accept an innovation or not. Therefore an entrepreneur has a strong financial interest in bringing a product or service onto the market that is embraced by the customers. Despite the importance of the entrepreneurs' role in the process of innovation adoption, most of the studies in the field of agriculture until now focused on the adoption strategies employed by the end-users - farmers (Pierpaoli *et al.*, 2013) That is why the research presented here will concentrate on the side of the innovators - agricultural startups. Analyzing this topic from the perspective of the agricultural startups can deliver additional understanding on the strategies that are needed to support an adoption of the innovations in the field of agriculture, which therefore might positively contribute to the increase in food production by 2050.

1.2 Objectives and research method

The main objective of this research is to investigate marketing strategies that digital agricultural startups use to achieve critical mass on the market. The problem of the digitalization of agriculture is common to industrial and industrialized countries (EIP-AGRI, 2015; Lele, 2017). As previously mentioned, since most studies in the field of agriculture about the diffusion of innovation are concentrated on the customer (farmer) side and customers' attitudes towards new technologies (Pierpaoli *et al.*, 2013), this work will focus on the companies' side to see if there are additional components to the diffusion of innovation theories that are not directly connected to the customer perspective. To begin with, digital agricultural startups will be defined and categorized. In the next step, a theoretical overview will follow. This should lead to the identification of the most important theoretical frameworks that are commonly used in the studies about innovation acceptance. This theoretical framework will serve as a guideline to the first qualitative inquiry of its kind that will be conducted with digital agricultural startups.

The qualitative method enables one to acquire deeper expertise regarding the topic; it helps discover new relations in the subject (Strauss and Corbin, 1998). After obtaining input about the marketing strategies of startups and their perception of the situation on the agricultural market, a new inquiry will be conducted. The new inquiry will test hypotheses based on the theory and new findings from previous qualitative inquiries to discover what kind of strategies are used in the startups that have already achieved critical mass.

The second qualitative inquiry will focus on the startups that offer farm management information systems in Germany. This technology was selected because it represents an element of the field called precision farming. Precision farming is one of the technologies that promises to increase the quantity and quality of future agricultural output, and at the same time, generate a positive impact on the environment (Schrijver *et al.*, 2016). This type of smart farming technology is also supported by the European Union, through diverse policies and funding tools. Therefore, it may also be interesting to discover whether any of the startups that work in the area will mention governmental policies as an additional support for achieving higher market penetration.

The design of this research is based on the post-positivist approach. In this theory, it is believed that the world is complex and that there is no single truth (O'Leary, 2004, p.6). Post-positivist research uses explorative methods to capture reality; it focuses on the system itself instead of certain small parts of it. The specific nature of this type of research is that the results are not always reproducible. However, there are particular verification methods for it, as well as a transparent explication of methods used to gather and analyze the data. Often, results obtained with the post-positivist method are used to develop a new theory or to offer a new generalizing approach that could be used in other areas beyond the field being researched.

2 The digital agricultural startup market

Climate change and a growing population have made governments in various countries change the way agriculture currently works. Digitalization creates new ways to produce and distribute food. The process of transformation in the agricultural sector has attracted startups that aim to introduce some of these digital technologies to new fields. According to the investment platform AgFunder, in 2017, approximately $10 billion were invested in agri-tech startups. The amount invested grew by nearly 30% in comparison with 2016. Of these $10 billion, approximately $2 billion were invested in startups that develop farm technologies. Approximately half of the $10 billion investment was aimed at online marketplaces and online shops for the agricultural products. In 2017, the investment in this sector also experienced a 30% increase.

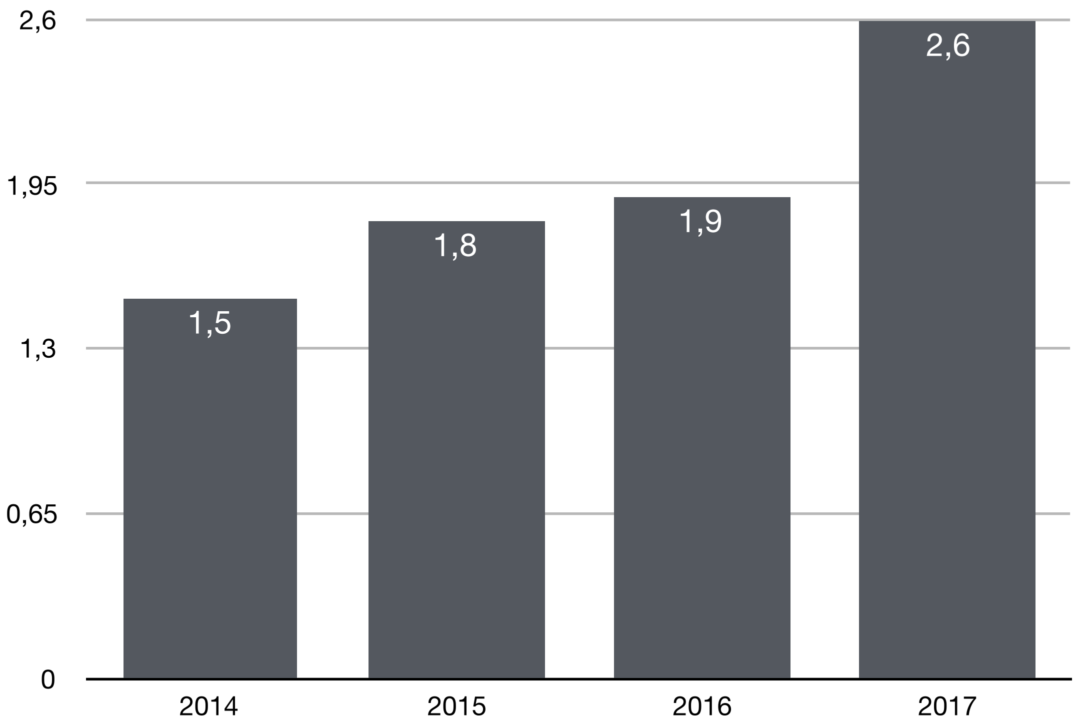


Figure 1: Financing of the farm technologies 2014-2017 (in $ billion) (Source: AgFunder, 2017)

In addition to startup investment, there are various scientific projects, such as “Hands Free Hectare” in the UK, or pilot projects and consulting programs with the use of the latest technology sponsored by the European Commission, all of which attempt to encourage farmers to start using digital technologies. The European

Innovation Partnership for Agriculture (EIP-AGRI) is a special initiative of the EU Commission that, among other tasks, brings innovators into the context of rural development. Another country that has announced digitalization of the agricultural sector as a part of their national policy is India. India is considered one of the most important global suppliers of agricultural products (Seth and Ganguly, 2017). More than 50% of the Indian population is involved in agriculture to sustain their livelihoods (Indian Ministry of Agriculture and Farmers Welfare, 2018). Political support of agri-tech has boosted investors' interest in this sector. In 2016, according to the Global Innovation Index, 34 ventures received $295 million in funding, which is "the highest investment amount recorded in India" (Seth and Ganguly, 2017, p.107). The policy changes in India in 2015 had a direct impact on the number of agri-tech startups. According to the data provided by the Indian Ministry of Agriculture and Farmers Welfare, there was a boom in the number of new agricultural ventures from 2014 - 2016. 2015 was the year with the highest number of newly- founded agri-tech startups.

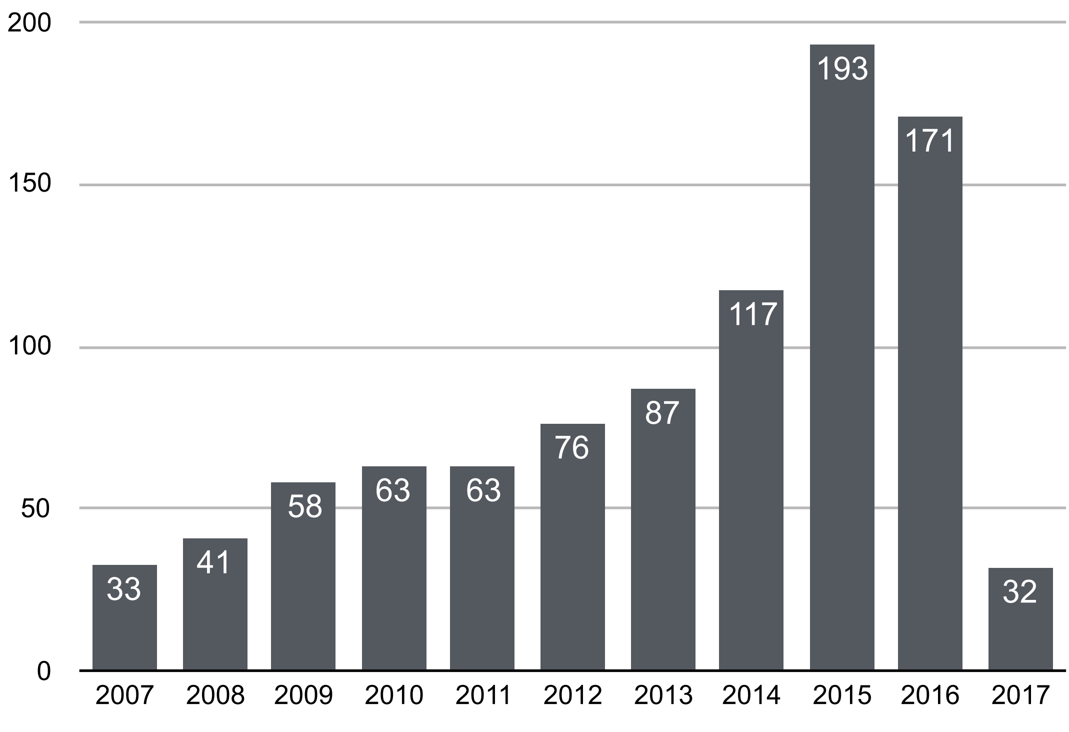


Figure 2: Number of the agri-tech startups founded in India 2007-2017 (Source: Indian Ministry of Agriculture and Farmers Welfare, 2018)

In 2016 the International consulting company Deloitte distinguished five agricultural trends that should attract investment in the future: food e-commerce, crop efficiency technologies, bio-chemicals and bio-energy, food technology such as meat substitutes, as well as contained and vertical farming. Most of these trends represent an alternative to classical farming, aiming at making it more sustainable. The pursuit of these new forms of farming are based on the negative impact of traditional farming that causes soil degradation, produces greenhouse gases, reduces biodiversity and makes some coastal areas unsuitable to life due to the extensive use of fertilizers (Goedde *et al.*, 2016). To reduce this negative impact, these new alternative farming models are becoming popular:

- Urban fields: abandoned industrial areas transformed into farmland;
- Greenhouses: hydroponics and rooftop greenhouses;
- Vertical farms;
- Sea farming.

In Italy, for example, according to the statistics from 2017, 50% of all agri-tech startups in the area of smart agriculture focused on environmental technologies; 35% of them are concentrating on precision farming (Statista, 2018). In the United States, urban gardening is receiving substantial funding and new ambitious projects are getting started, e.g. the American startup Iron Ox, which created an 8,000-square-foot indoor farm to produce lettuce and herbs, and employs robots instead of humans to harvest. The robots are controlled by a program called "Brain". This program monitors growing conditions and brings all the nutrients involved into balance (Vincent, 2018). Another trend comprises of vertical farms, which should save costs and optimize the output. In Japan, one of the largest vertical farms in the world produces 30,000 heads of lettuce per day, according to the farm's website (Technofarm, 2018). In the United States, vertical gardening is also being taken seriously: the startup Plenty received $200 million (until now the largest agri-tech investment) to build several towers that are used to grow lettuce and herbs. The towers will be equipped with LED lamps, cameras and sensors to monitor plant growth (Roberts, 2018). The data collected at such vertical warehouses should be used by agronomists who, along with artificial intelligence experts, should develop algorithms to improve the vertical farming system.

2.1 Definition and classification of digital agricultural startups

Lately, the word startup has been appearing more often in the press; almost all new ventures are currently being termed as “startup”. However, is it true that these days, all new ventures are startups? Are there any specific characteristics to distinguish a startup from other new ventures on the market? The first definition of the term could be tracked back to 1979: it was defined as a stage where a decision about founding a company and how to position it on the market is made (Schendel *et al.*, 1979). In the late ´90s, this term was used to refer to newly-founded companies that deal with electronic technologies and the Internet. One of the typical characteristics of those ventures was growth speed – so-called scalability. Scalability means that the business could be easily expanded with minimal costs. Scalability became possible thanks to information technology that makes marginal costs almost equal to zero and eliminates classical distribution costs. Eric Ries, with his book “Lean Startup”, popularized the ways startups developed innovations and brought them onto the market in the early 2000s. From his perspective, “a startup is a human institution designed to create a new product or service under conditions of extreme uncertainty” (Ries, 2011, p.37). The key word in this definition is uncertainty. From Ries’s perspective, startups challenge existing rules on the market and are open to experimenting. They do something completely new that did not, up until that point, exist on the market. This means that from Eric Ries’s perspective, if one opened another online shop today, it would not be a startup anymore, because the processes of opening an online shop and making sales through this channel already exist. One would just replicate those for one’s product. Therefore, there is no uncertainty about how to do this and how it is going to be accepted.

With time, startups became part of the statistical observation indirectly showing the innovativeness of a country or region. Through implementing different kinds of monitors to keep track of these new ventures, new definitions also appeared. For example, the European startup monitor describes startups as companies that are younger than 10 years, offer innovative technologies and / or business models and have significant employee and / or sales growth (Kollmann *et al.*, 2016). In India, the government, with the launch of its initiative “Startup India, Standup India”, officially defined a startup as a business entity that is younger than 7 years (10 years for biotechnology startups) and is registered as a Limited Liability Partnership with a turnover of less than approximately 3175 EUR[1] for any of the financial years. Another criterion is that it must work on innovations or improvement of its products / services. It must also have a scalable business model (Startup India, 2018). In the United States, there is no official definition of a startup, though there are specific policies to support this type of company, such as "The Startup America Initiative", developed under the Obama government (National Economic Council, 2011). All the definitions presented above have one common element: innovativeness. Startups are young companies that challenge the existing processes and products on the market and bring a certain degree of "creative disruption" (Schumpeter, 1947). However, since research presented here has a particular interest in digital startups, another important element will be considered for the definition: scalability. For the purpose of this analysis, a "startup" will be defined as a new venture that offers scalable innovation in the form of new services, products, processes or business models and that has been on the market for no longer than 5 years.

Now, using this definition of the term "startup", it is important to understand the types of technologies agricultural startups are dealing with. To do so, an overview of the existing and upcoming digital agricultural technologies will be presented below. The AgFunder Investment Platform (2017) suggested 13 categories of agricultural innovations, among which are:

- Ag Biotechnology (genetics, microbiome, breeding etc.);
- Farm Management Software, Sensing and Internet of Things (data collection, data analysis and support for on-farm site decisions);
- Farm Robotics, Mechanization and Equipment (automation, drones, planting equipment);
- Bioenergy and Biomaterials (non-food extraction and processing);
- Novel farming systems (indoor farms, aquaculture, insect and water plants farms);
- Supply Chain Technologies (traceability tech, logistics);

[1] The currency exchange rate on 1 December 2018

- Agribusiness Marketplaces (commodity trading platforms, online input);
- Innovation food (cultured meat, novel ingredients);
- In-Store Retail and Restaurant Tech (Self-stacking robots, 3D food printers food waste monitoring);
- Restaurant Marketplaces (Tech platforms delivering food);
- eGrocery (online shops and marketplaces for the sale and delivery of agricultural products to consumers);
- Home and Cooking Tech (smart kitchen appliances, nutrition tech);
- Online Restaurant and Meal Kits (pre-portioned ingredients to cook at home).

The Organization for Economic Co-Operation and Development (2018) sees agricultural innovations as an effective way to globally sustain a high quality of food. One of the technologies that should contribute to this aim is precision farming. In the Scientific Foresight Study prepared by the European Parliamentary Research Service, precision farming was defined as “a modern farming management concept using digital techniques to monitor and optimize agricultural production processes” (Schrijver *et al.*, 2016, p.4). This technology should help to “increase the quantity and quality of agricultural output while using less input” (Schrijver *et al.*, 2016, p.4). In this way, precision farming should not only solve the problem of food supply but also have a positive impact on the environment. According to the Global Innovation Index 2017, digital agriculture is “a deployment of computational and information technologies in farming which will play a key role in achieving innovation goals” (van Es and Woodard, 2017, p.97). This type of technology should optimize and individualize all the processes within agriculture. According to the Association for European Agricultural Machinery (CEMA, 2017), precision farming is only a part of the digital evolution of agriculture, because the final target is a connected, knowledge-based production system. In other words, the precision farming concept is only a small part of digital agriculture, wherein one of the ultimate goals is optimal decision functions that help to better assess and manage agricultural risk (Shen *et al.*, 2010, p.42).

For the purpose of this research, digital agricultural technologies will be defined in accordance with the definition of the Global Innovation Index as “a deployment of computational and information technologies" that should optimize and individualize the agricultural processes (van Es and Woodard, 2017, p.97). For the initial qualitative inquiry, this definition will be used to select startups worldwide for the interviews. For the following investigation of marketing strategies of the startups that achieved critical mass, precision farming as the most supported and promising technology shall be selected.

2.2 The role of startups in the digitalization process of the agricultural industry

Another important question is: what role do agricultural startups play in the digitalization process? Why do already existing major corporations not lead the process of agricultural transformation? One of the biggest differences between corporations and startups is the structure. A startup has almost no hierarchy, which makes the decision-making process agile. Agility is an important quality if one works under conditions that change rapidly. Moreover, startups, from the very beginning, are customer-oriented because they need to survive on the market. To do so, they work hard to recognize and satisfy customer needs (Owens and Fernandez, 2014, p.14). They learn quickly from their failures and, accordingly, adjust their products. Ries called this type of work "lean startup" (Ries, 2011). Although the lean concept originates from the Toyota corporation, this way of working was more rapidly adopted by startups than by other corporations (Ries, 2011). This agile way of working is a necessity when a completely new product is launched on the market. Since there is no similar product or process, it is hard to forecast customer reaction; this means that a company should be ready to change the original product and adapt it to the market demand.

Looking at the last 20 years and the most commonly used technologies today, such as the Google search engine, the first personal computer, Microsoft Office or Amazon, all these technologies were brought to the market by startups. Another aspect that unites these companies is the attitude toward supporting creativity. According to Martins' and Terblanche's model (2003), there are several determinants that influence the level of a company's innovativeness. These determinants are often reflected exactly in startup companies. The table below shows the key determinants of a company's culture that support creativity and innovation.

Strategy	Structure	Support mechanisms	Behavior that encourages innovation	Communication
vision and mission	flexibility	reward and recognition	mistake handling	open communication
purposefulness	freedom	availability of resources	idea generating	
	cooperative teams and group interactions		continuous learning culture	
			risk-taking	
			competitiveness	
			support for change	
			conflict handling	

Table 1: Determinants of organizational culture that influence innovation and creativity (adopted from Martins and Terblanche, 2003)

Some larger corporations have already realized the importance of the startup culture and try to imitate it. However, oftentimes, the corporations just copy the outer attributes of the startups, such as office design, without taking along the intangible values like culture and mind-set (Owens and Fernandez, 2014, p.13). According to an article in the Harvard Business Review, the once-successful company Kodak could not embrace the innovations on the market because there was no company culture supporting it and the management did not really recognize the opportunities of the new trends and did not support their own innovative technologies (Anthony, 2016).

Entrepreneurs are famous for recognizing new market opportunities. Their ability to do this is so extraordinary that it became subject of a research field (Baron, 2006, p.104). To attract the attention of entrepreneurs to such a conservative field as agriculture, governments in various countries launched special programs to attract investors and to provide certain funds to develop new technologies. India is one of the countries that officially proclaimed their readiness to digitalize rural communities in 2015 (Bergvinson, 2017). To track the changes due to this new

Indian government policy, one must observe the entrepreneurial development in this sector. The Indian Ministry of Agriculture and Farmers Welfare published the first statistics about startups in the agricultural sector. According to this statistical data, there are several agricultural startup hubs in India in different regions, e.g. Maharashtra, Karnataka and Andhra Pradesh, where more than 150 startups have their headquarters (Indian Ministry of Agriculture and Farmers Welfare, 2018).

Some Indian newspapers are slowly collecting the first success stories from the farmers in these regions, who are starting to implement new technologies such as solar-powered cool storage, which helps preserve the products longer and, therefore, helps farmers negotiate better prices. Another new technology is the low-cost irrigation controller, which has so far been installed in 65 farms in the Karnataka and Andhra Pradesh regions (Shankar and Vignesh, 2016). However, it is important to mention that without additional infrastructural support, which the Indian government is offering, such changes would hardly be possible. The government started such projects as "digital villages" ("A Digi Goan"), which provides high-speed connectivity and wi-fi hot spots in rural areas (The Economic Times, 2018). After the first 6 pilot projects, the Indian government plans to implement internet connectivity in 700 villages across the whole country (Shankar and Vignesh, 2016). The general impact of the agricultural startups on digitalization is still difficult to properly estimate, not only because of the scarce amount of statistical data, but also because of the different governmental policies that support certain types of technology or certain regions at a different rate. They also define what kinds of companies could be called "startups" differently. Thus, it is hard to say whether farmers started using this technology because they recognize its benefits or because the government pushed it and subsidized the startups that produce it.

2.3 Challenges of startups on the way to critical mass

According to the McKinsey report, the first investments in agri-tech were undertaken as early as 2004 (Goedde *et al.*, 2015). However, 14 years later there are few technologies that have a high market penetration rate.

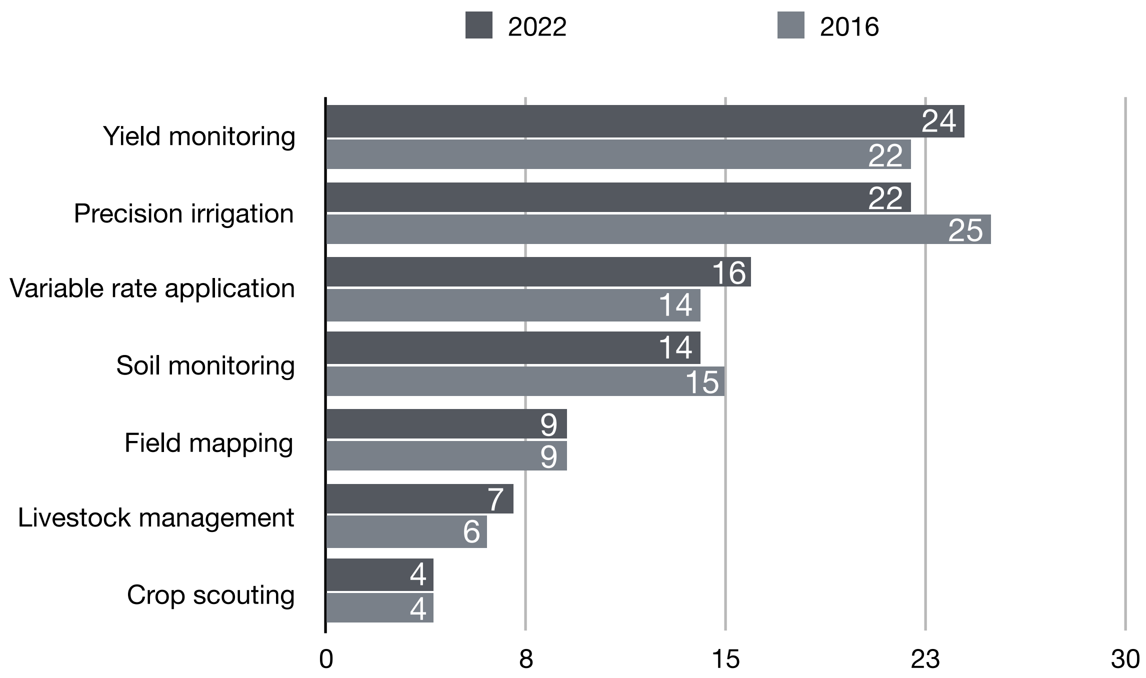


Figure 3: Global agricultural Internet of Things market size, by application in % for 2016 and predicted for 2022 (Source: Statista)

According to the statistics, the most promising smart agriculture technologies worldwide are yield monitoring and precision irrigation (Figure 3). Meanwhile, there are technologies such as field mapping or crop scouting that, according to the statistics, will stagnate in the upcoming years.

The stagnation and lack of technology acceptance represent one of the biggest challenges for agricultural startups. Among precision farming technologies, according to the forecast prepared by Statista, precision fertilizers will be the market segment with the highest market volume by 2050 (Figure 4). Moisture sensing and precision sensing will have the lowest market volume. It is interesting that although precision irrigation currently has the highest market penetration rate, its market value by 2050 will be much lower than the one of precision fertilizers (Figure 4).

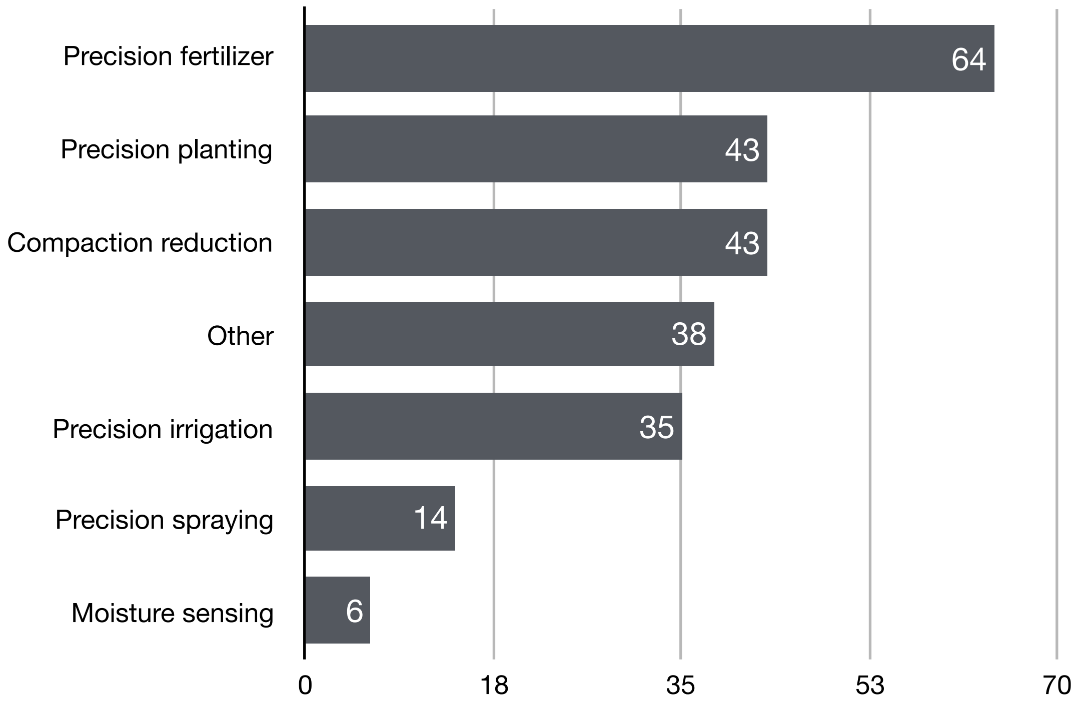


Figure 4: Estimated addressable market for precision farming worldwide by 2050, by technology (in $ billion) (Source: Statista)

Beyond the innovation acceptance challenge, which encompasses many different factors that will be presented in more detail in the following chapter, there are general challenges for startups. These challenges must be met in order for startups to survive on the market, independent of the industry involved.

According to the consulting agency Startup Genome, which tries to find answers to the question of what makes startups succeed or fail, it was discovered that 90% of all startups do not survive on the market (Marmer *et al.*, 2011). The consulting agency CB Insights investigated 101 post-mortem stories of startups and managed to identify the top 20 reasons why startups fail. The most important reason, causing more than 40% of startups to shut down their activities, is that they could not correctly estimate the market need. According to the EIP-AGRI (2015), composed of 19 experts in the field of agriculture, one of the main reasons why famers in the EU do not use precision farming is that they do not see the benefits of the technology. Properly presenting the benefits of the technology that match the farmers' needs seems to be one of the crucial tasks that agricultural startups need to consider if they want to survive and achieve critical mass on the market. Below, all 20 reasons discovered by CB Insights are presented.

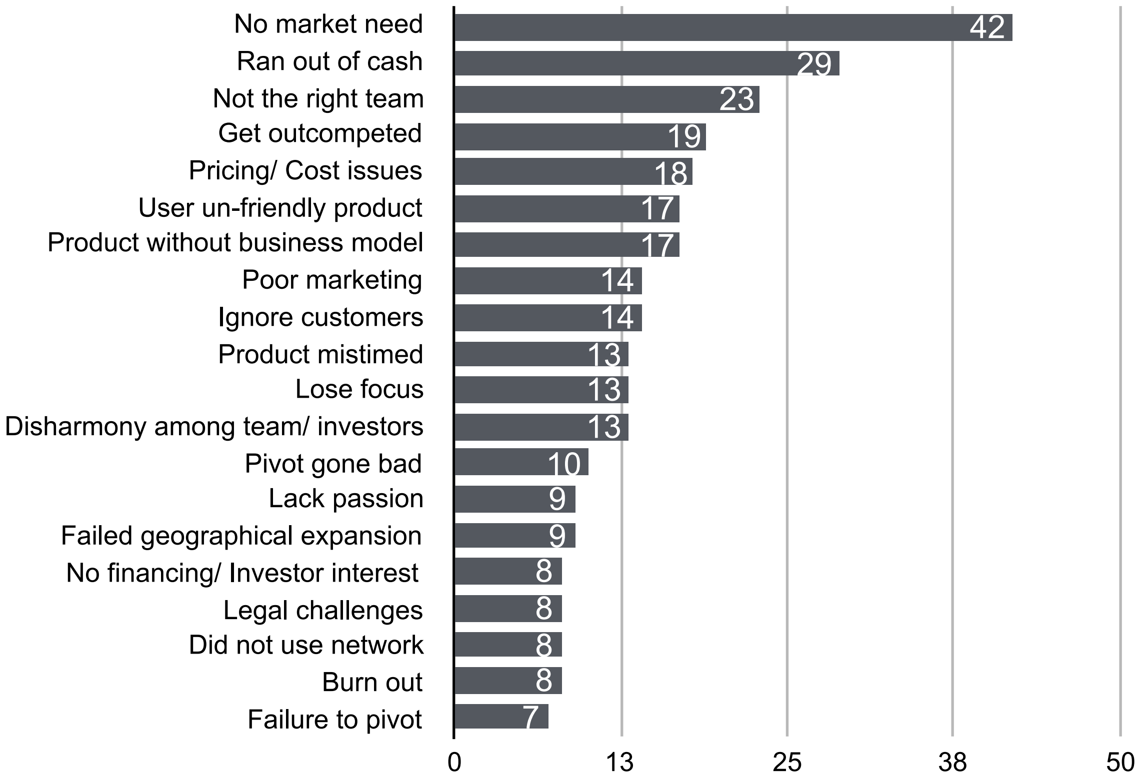


Figure 5: Top 20 reasons startups fail in %, out of 101 startups interviewed (Source: CB Insights)

For the purpose of the research presented here, it is also interesting to investigate the kinds of barriers for technology adoption startups perceive on the market if they also find it difficult to detect the farmers' needs and to develop a product accordingly. Perhaps there are additional obstacles on the agricultural market that are specific to this industry and can also cause a startup's failure.

3 Theories about innovation acceptance and critical mass

Critical mass is the outcome of innovation acceptance. That is why, firstly, it is important to understand the concept of innovation acceptance, since the existence of critical mass depends on it.

3.1 Main theories about the acceptance of innovation

In the research presented here, special attention will be paid to the four basic and most used models in scientific literature: Technology Acceptance Model (TAM), Unified Theory of Acceptance and Use of Technology (UTAUT), Theory of Planned Behavior (TPB), and Theory on Diffusion of Innovation (DOI). Although there are currently more models for the prediction of technology acceptance, the ones cited here have often been the basis for the development of models meant to calculate the rate of innovation adoption (Taherdoost, 2018).

The first synthesized theory that explained what factors play a decisive role in the technology adoption process was created by Everett Rogers in 1962. To develop the Theory on Diffusion of Innovation, Rogers used several disciplines such as sociology, communication, anthropology and economics. Thanks to the interdisciplinary approach, Rogers (1983) adapts a critical mass phenomenon that originally comes from sociology to explain and to quantify the moment when innovation could count as having been accepted by the users.

The Theory of Planned Behavior and the Technology Acceptance Theory have their roots in the Theory of Reasoned Action (Venkatesh and Davis, 1996; Ajzen, 1991). The Theory of Reasoned Action (TRA) was developed by Ajzen and Fishbein in 1975 and explained the behavioral intention or, in the present case, decision to start using technology due to two factors: information and silent beliefs. Information influences the attitude of a person toward a technology; silent beliefs are part of our subjective norms that could be, for example, general perceptions of a technology’s usefulness. Ten years later, in 1985, Icek Ajzen added a new component to TRA. Thus, the Theory of Planned Behavior was born. TRA and TPB both originate from psychology. That is why the initial research fields of TPB were human habits, especially bad ones, like smoking and drinking. With time, the number of application fields grew, including the field of innovation adoption behavior.

The Technology Acceptance Model was first suggested by Davis (1989) in his dissertation in the area of economics. TAM aimed to explain what factors influence the adoption of information technologies using psychological elements. Over time, this model was modified and enhanced several times, involving more determinants to increase its explanation potential. One of such models will be presented below.

Finally, the last model, the Unified Theory of Acceptance and Use of Technology, presented by Venkatesh *et al.* in 2003, represents the latest synthesized theory meant to explain the adoption of innovations. It includes components of the models presented above and their modifications, as well as two additional models from social psychology.

3.1.1 Diffusion of Innovation

The theory about the Diffusion of Innovation was the first interdisciplinary theory that tried to explain what factors influence the decision to accept an innovation. Within this theory, it is possible to separate several important groups of factors that influence the adoption process: technology aspects and the channels employed to reach potential users.

From the technological perspective, Rogers (1983) identified five important characteristics that a new technology should have to be accepted by potential users: relative advantage, compatibility, complexity, trialability and observability.

Relative advantage is a user perspective of the benefits that a new technology provides. To measure relative advantage, not only economic indicators such as yield gain or cost reduction could be used but also intangible determinants such as satisfaction or convenience. “The greater the perceived relative advantage of an innovation, the more rapid its rate of adoption is going to be” (Rogers, 1983, p.15).

The next criterion is compatibility, which represents a degree of consistency with existing norms and values in the social system. The higher the compatibility is, the higher the odds that the innovation will be accepted. The level of perceived difficulty to understand or use the technology is defined as complexity. Rogers (1983) writes that generally, the innovations that are easy to understand are adopted rapidly, in comparison to the ones where one must acquire new skills or knowledge. Trialability could be described as an opportunity to try the innovation on a certain, limited basis without a commitment to acquire it. This opportunity decreases the level of uncertainty about the technology. Uncertainty plays a crucial role in the innovation-decision process, because, as Rogers (1983) describes, “it is essentially an information-seeking and information-processing activity in which the individual is motivated to reduce uncertainty about the advantages and disadvantages of the innovation.” The last criterion is observability, which is defined as a certain degree of result visibility. Some of the criteria suggested by Rogers (1983) can also be found in the TAM and in TPB.

The role of these five characteristics of innovation were tested in various studies in the field of agriculture. In the study about Cambodian farmers who should adopt rhizobium bacteria, Farquharson *et al.* (2013) found out that only two factors out of five suggested by Rogers (1983) were significant: relative advantage and observability. In the study about the adoption of integrated pest management by cotton farmers in India, 99% of the variance could also be explained by two characteristics of the model: relative advantage and level of complexity (Peshin, 2013). These two innovations have different backgrounds: one represents a biological innovation and the other a technological. This could mean that for the different types of innovation, one or the other characteristic can play a more important role, but relative advantage, independent of the innovation, appears to be a significant criterion.

A further important factor influencing the diffusion process is the channels that companies use to acquire new customers. According to Rogers (1983), there are two major important channels to spread information about an innovation: mass media and interpersonal channels. These channels play an important role in the decision-making process, because the first step before a decision is made is gaining knowledge about the innovation. This is followed by persuasion, which is based on the individual's attitude toward the innovation. Rogers (1983) separated two groups of "knowers of innovation": earlier and later knowers. These types of knowers have different exposures to the knowledge sources and different levels of trust in different sources of knowledge. The earlier knowers have a higher exposure to the knowledge from mass media, change agents and interpersonal channels due to larger personal networks in comparison with later knowers. But knowing about the innovation is not enough if the potential user does not recognize its usefulness. Based on these two important components of the theory, it is possible to represent the model for decisions-to-adopt as following:

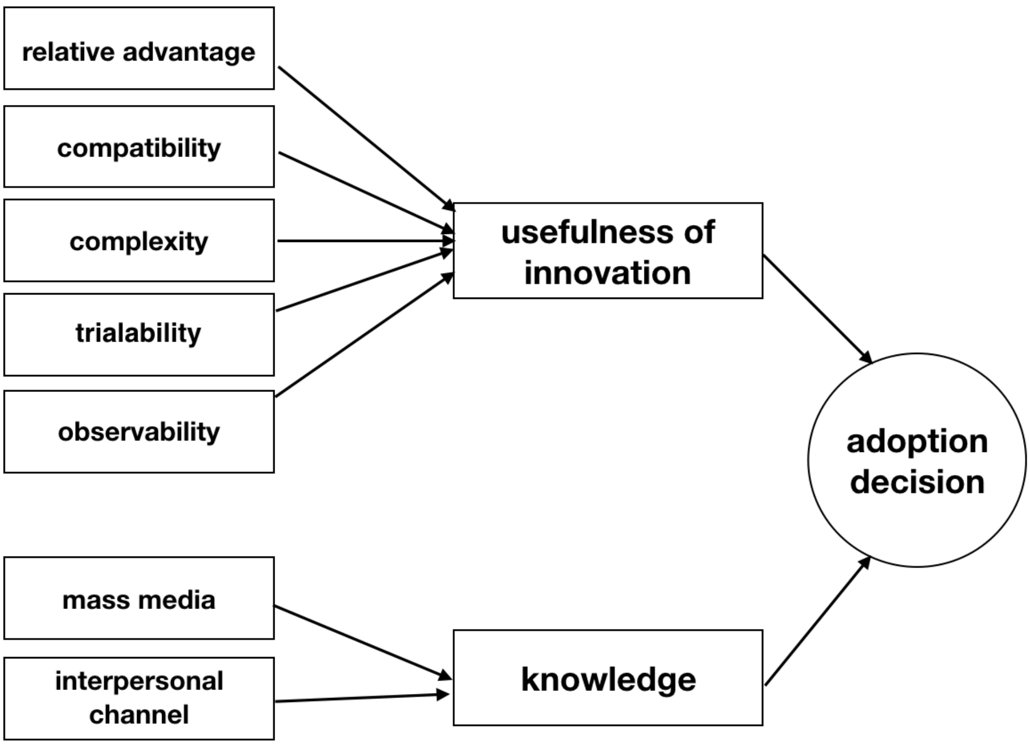


Figure 6: Factors that influence the decision to adopt according to Rogers (1983)

3.1.2 Theory of Planned Behavior

Another important theory in the area of innovation acceptance is the Theory of Planned Behavior (TPB) that has its roots in psychology. TPB is an extension model of the Theory of Reasoned Action that was developed by Fishbein and

Ajzen (1975). Both models explain behavior based on the intention that it is influenced by certain determinants like attitude and social perceptions. In addition, TPB has determinant-perceived behavioral control. TPB explains the individual's behavior as "a joint function of intentions and perceived behavioral control" (Ajzen, 1991, p.185).

Intentions are "indicators of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform their behavior" (Ajzen, 1991, p. 181). Behavioral control is a person's perception of his/her resources and/or opportunities (like money, time, skills etc.) that dictate his/her behavior. Basically, Ajzen (1991) writes that these two components of human behavior are nothing but motivation and the ability to do something. When behavioral control is low, then behavior mostly depends on intention. Intention is described by Ajzen (1991) as influenced by three independent determinants: attitude, subjective norm and perceived behavioral control. At the same time behavior control can also directly influence behavior.

Attitude is defined as the level of individual estimation of certain questions/ situations. Attitude is determined by the belief of an individual about the outcomes of certain behavior and his/her own personal beliefs.

Subjective norm represents the level of social influence on the performance of an individual. This component is influenced by the normative beliefs and the motivation to comply with them.

The third determinant that influences intention is perceived control, which "is determined by control beliefs concerning the presence or absence of facilitators and barriers to behavioral performance, weighted by their perceived power or the impact of each control factor to facilitate or inhibit the behavior" (Glanz *et al.*, 2008, p.71). The decision-making process described by Ajzen (1991) could be presented as follows :

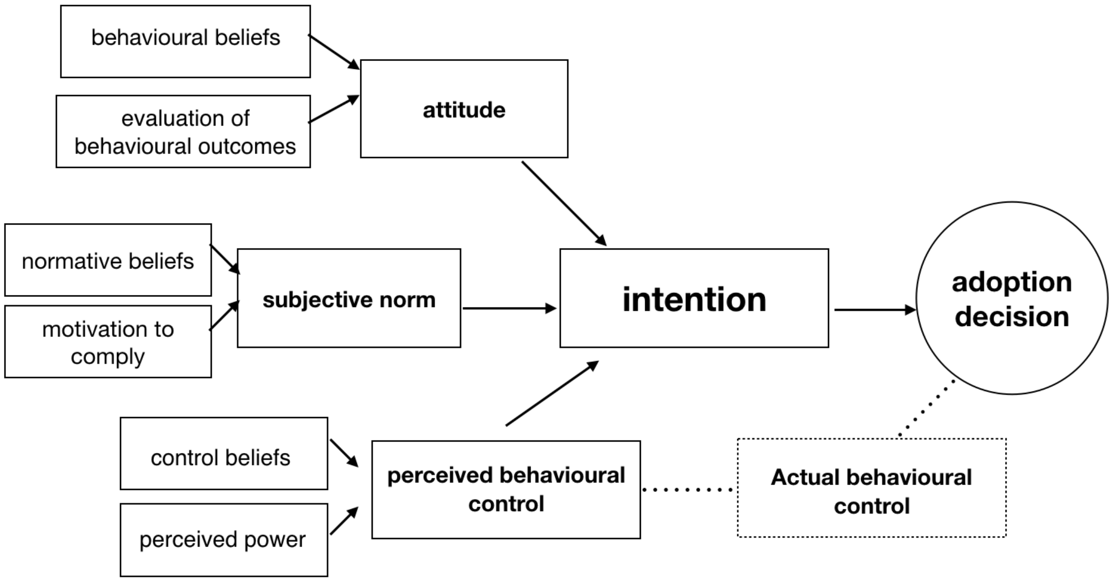


Figure 7: Factors that influence the decision to adopt. Modified model of Icek Ajzen

To use TPB, certain conditions should be considered: 1) the context in which behavior takes place stays the same; 2) intentions and behavioral control do not change in the assessment interval; 3) the perception of behavioral control reflects a realistic control. It is also important to define target, action, context and time in which behavior takes place. Ajzen also developed a special construct for creating TPB questionnaires that includes examples of questions for the measurement of attitude, perceived norm, perceived behavioral control, intention and past behavior. For the measurement, a Likert scale with 7 points is used, which ranges, for example, from “extremely good to extremely bad” or “strongly agree to strongly disagree”[2].

The TBP model was widely spread in the health studies in the past which analyzed unhealthy habits such as smoking and drinking, for example (Glanz *et al.*, 2008). In agriculture, TBP was used to test the acceptance of various innovations or practices, e.g. for the adoption of soil conservation (Wauters *et al.*, 2010), acceptance of organic farming (Hattam 2006; Läpple and Kelley, 2010), adoption of improved grasslands (Borges *et al.*, 2014), conservation (Beedell and Rehman, 1999), animal welfare practices (Lauwere *et al.*, 2012; Bruijnis *et al.*, 2013), tree planting (Zubair and Garforth, 2006; Meijer *et al.*, 2015) and water conservation

[2] A sample questionnaire is available on the website of University of Massachusetts Amherst http://people.umass.edu/aizen/pdf/tpb.questionnaire.pdf (04.12.2018)

practices (Yazdanpanah *et al.*, 2014). In the study conducted by Wauters *et al.* (2010), for example, the TPB established the variance of the acceptance of soil preservation at between 44% and 70%. In the study about tree-planting, Zubair and Garforth (2006) confirmed that the theory offers a structured and replicable framework that helps predict behavior based on beliefs, social referents and perceived behavioral control.

3.1.3 Technology Acceptance Model

The Technology Acceptance Model (TAM) has two main components that explain the adoption of a technology: perceived usefulness and the perceived ease of use (Davis,1989). The first component of the model, usefulness, is defined as a level of an individual's perception about the impact of an innovation used on his or her job performance. If an individual believes that an innovation has a positive impact on his/her performance, then it is defined as useful. The second component of the model, ease of use, is based on the individual's perception of the amount of physical or mental effort that must be invested in order to use the innovation. In other words, each individual measures the benefits that could be obtained using the technology and the obstacles to using the technology, because each individual has a limited quantity of effort that he/she is prepared to invest in it.

These two components were selected by Davis (1989) based on previous research and studies, where different scales were applied to find significant factors that had an impact on the decision-making process. Perceived ease of use was selected based on research about self-efficacy, where it was presented as "the basic determinant of user behavior" (Davis, 1989, p.321). Self-efficacy is a personal estimation of how well an individual can execute certain actions to achieve certain results. Davis (1989) excluded the cost-benefit approach from the model based on the theoretical suggestions of Beach and Mitchell (1978) that an individual, during the decision-making process, acts subjectively and not objectively.

To measure the perceived usefulness and ease of use of information technologies, Davis (1989) developed and tested a specific scale with various assumptions. The initial scale had 14 items for each component. The analyzed results of the first study showed that only 6 items were relevant. The second study confirmed the results. According to those results, usefulness correlated with the usage of technology and could be described with the following terms: “work more quickly”, “job performance”, “increase productivity”, “effectiveness”, “makes job easier”, “useful”. In the case of the ease of use, the following terms correlated with the usage of technology: “easy to learn”, “controllable”, “clear and understandable”, “flexible”, “easy to become skillful ”, “easy to use”.

Since the publication of the TAM, it has become a robust model that can explain up to 40% of the variance in the data (Venkatesh and Davis, 2000). Nevertheless, Venkatesh and Davis (2000) extended the model and enhanced its construct by adding more determinants. According to the improved model, the following components influence perceived usefulness: experience, subjective norm, image, job relevance, output quality, result demonstrability and voluntariness. These new determinants were divided into two larger groups: social influence and cognitive process.

Subjective norm, voluntariness and image were part of the social influence process. Subjective norm and voluntariness were both part of a person’s perception of what the social factors in their respective culture expect an individual to do. In the case of subjective norm, the decision to adopt takes place under mandatory conditions; in the case of voluntariness, this decision is determined by non-mandatory conditions. Image is defined as the social status of an individual that can be improved in case they choose to use the innovation.

The cognitive group of determinants includes job relevance, output quality, result demonstrability and perceived ease of use. Job relevance is defined as the degree of relevance of an innovation for the fulfillment of certain job tasks. The output quality is an individual’s perception of the quality of the task achieved with the use of the innovation. To be able to estimate the quality of the task, the results should be visible to the individual. That is how result demonstrability is defined. To test the model, Venkatesh and Davis (2000) conducted four empirical studies with different companies and different research objectives. The results of those studies confirmed the robustness of the model, as new determinants helped explain up to 60% of the variance for intention to use an innovation. The following graph visualizes the constellation of factor dependencies on the decision to adopt new technology.

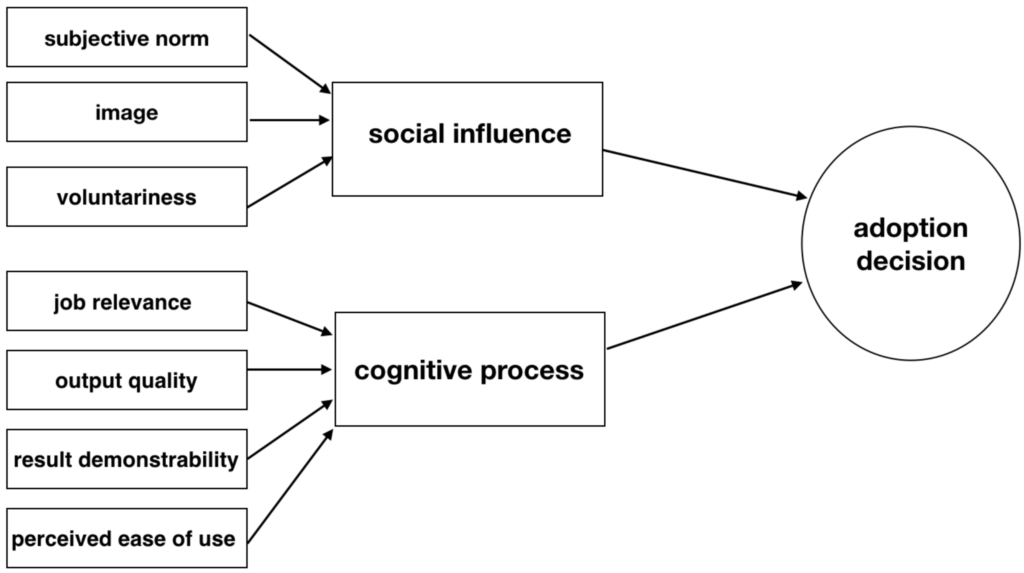


Figure 8: Enhanced TAM (based on Venkatesh and Davis, 2000)

TAM and its extended versions were actively used in the field of agriculture to predict the adoption of information and communication technology (ICT), e.g. ICT use by the Agricultural Extension agents in West Azerbaijan. There, the original model was enhanced by adding two additional determinants, experience and the company's willingness to fund, which influence the cognitive process. This enhanced model could explain 64% of behavior changes (Alambaigi and Ahangari, 2015). Far and Rezaei-Moghaddam (2017) investigated the acceptance of precision farming technology by Iranian agricultural consultants by using the enhanced TAM. In this study, additional determinants such as confidence and personal innovativeness were used to predict the decision of using the technology. The results of the study could explain 56% of the variance in behavioral change.

3.1.4 Unified Theory of Acceptance and Use of the Technology

The fourth model is the Unified Theory of Acceptance and Use of the Technology

(UTAUT). This model was developed based on all models described above and several other extensions thereof. Venkatesh *et al.* (2003), in their literature review of technology acceptance models, criticized the results obtained by the TAM studies because almost all studies were conducted with students. The measurements took place after acceptance or rejection of the technology and not during the process of the decision-making. The context and the nature of the measurements were also criticized by the authors. They conducted a longitudinal study, where they used several scales to measure the acceptance of technology including the one suggested by Davis (1989). The results of this study helped determine factors that impact the user's acceptance and adoption behavior: performance expectancy, effort expectancy, social influence, and facilitating conditions (Venkatesh *et al.*, 2003, p.447).

Performance expectancy was defined as "the degree to which an individual believes that using the system will help him or her to attain gains in job performance" (Venkatesh *et al.*, 2003, p.447). Effort expectancy is the perceived easiness of the technology's use. Social influence describes the level of perception of a person regarding how their use of an innovation will be viewed within society or by specific important individuals. Facilitating conditions represent technical and organizational conditions that make the use of innovation possible and/or easier.

After these four important factors were defined, the authors measured whether these factors have different effects depending on the following determinants: gender, age, experience and voluntariness to use. According to the results obtained, performance expectancy and social influence were important for the innovation acceptance independent of those determinants. Effort expectancy is more significant for women and elderly people. Facilitating conditions are significant only in the case of older workers. The model of the decision-making process based on the UTAUT is shown below.

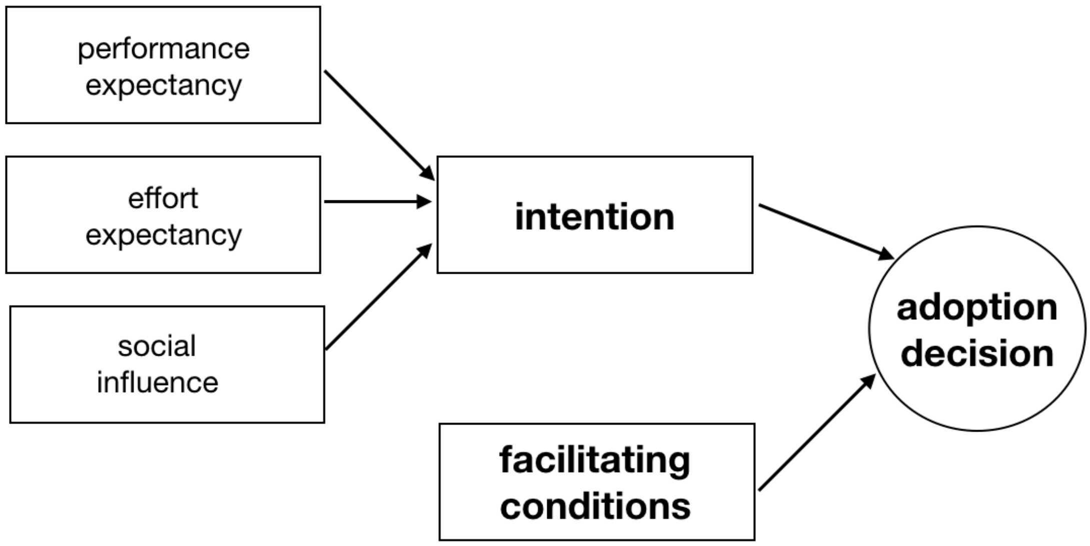


Figure 9: Factors influencing the decision to adopt according to UTAUT (based on Venkatesh *et al.*, 2003)

This model, in combination with the theory about the Diffusion of Innovation, was used to explain the use of ICT by Malaysian farmers (Mahamood *et al.*, 2016). The combined model could explain 10.2% of the variance. As a result, the authors suggested further adjustment of the model. Another study in the area of ICT, conducted among agricultural extension officers in Kenya, could explain 56% of the variance (Kahenya *et al.*, 2014). The model helped find a strong correlation between improved productivity, facilitating conditions and management support that influenced the use of ICT. However, the authors also suggest improving this model for further studies.

The theories presented above have certain determinants that were partly used in other models. However, neither of the models can explain 100% of the variance; even their combinations, as in the case of UTAUT, do not necessarily provide better results. In Table 2 below, the factors mentioned by the different theories were grouped according to technological, psychological and communication aspects that play an important role in the decision-making process regarding innovation adoption.

Technological aspects	**Psychological aspects**	**Communication aspects**
Usefulness (DOI, TAM, UTAUT)	Subjective norms / Social influence (TPB, TAM, UTAUT)	Mass media (DOI)

Technological aspects	Psychological aspects	Communication aspects
Ease of use (DOI, TAM, UTAUT)	Intention (TPB/ UTAUT)	Interpersonal channels (DOI)
Compatibility (DOI)	Perceived behavioural control / facilitating conditions (TPB, UTAUT)	
Trialability (DOI)		
Observability (DOI, TAM)		

Table 2: Technological, psychological and communication aspects that influence the decision to adopt

According to Table 2, from the technological perspective, two aspects were mentioned in three out of four theories: usefulness and ease of use. From the psychological aspect, subjective norms or social influence were also important factors that influenced the decision-to-adopt, according to three out of four theories. Communication aspects were mentioned only in the theory on the Diffusion of Innovation. However, those aspects relate to psychological aspects such as social influence, communicated through either mass media or interpersonal channels; these also have an influence on the decision to adopt. When the main factors regarding the decision to adopt have been identified, it is important to quantify the critical mass and to understand how many users need to positively decide to use new technology so that critical mass can be achieved. Also, it must be discovered whether there are additional factors that should be considered in each special case.

3.2 Definition of critical mass and the market barriers on the way to its achievement

3.2.1 Definition and measurement of critical mass

Critical mass became a popular phenomenon in several fields of study, ranging from sociology to economics. In 1978, in the field of sociology, Granovetter described a threshold model, wherein a threshold is “the number or proportion of others who must make one decision before a given actor does so” (Granovetter, 1978, p.1420). The concept of a threshold was the basis for the definition of critical mass in the theory about the diffusion of innovations. Later, Rogers defined critical mass as “the minimal number of adopters of an interactive innovation for the further rate of adoption to be self-sustaining” (Rogers, 1983, p.720). To explain the minimal number of adopters, Rogers (1983) divided consumers into different types of adopters due to their threshold level in the decision-making process. He also created a sequence of each group of adopters that influence the following group to participate in the process of adoption. Rogers (1983) identified five groups of adopters that adopt innovation in the following sequence: 1) innovators, 2) early adopters, 3) early majority, 4) late majority and 5) laggards. Each of these groups has certain characteristics that unite the consumers in them.

The first group of adopters, innovators, are well-informed consumers who use a wide range of information sources. They are not dependent on the subjective norms, since they are the first who try new things. They are better equipped to adopt complex products and also have substantial financial resources for their trial-and-error process. “The innovator plays a gate-keeping role in the flow of new ideas into a social system” (Rogers, 1983, p.248).

The next group are early adopters, who are more strongly integrated into the social system and act as opinion leaders. Rogers refers to such an individual as “an individual to check with before using a new idea” (Rogers, 1983, p.249). This is a decisive group for the success of innovation diffusion, because this group of potential users is eager to try new products and services on the market and ready to invest their time and money in them. Social prestige, the wish to become a trend-setter and the wish to preserve the esteem of others are their motivational factors. Malcolm Gladwell (2001), in his book about the tipping point calls early adopters “visionaries”. They are ready to take risks and then present their conclusions about the new technology to their peers. Normally, early adopters have a higher social status and better education. Some of them even use a new technology to achieve a higher social status. In terms of agriculture, Rogers (1983) describes several studies that showed that farmers with larger units adopt new technologies more often and earlier than the rest of the market. Early adopters are also extremely well connected. Rogers (1983) describes their role in the process of the diffusion of innovation as minimizing uncertainty about new innovations. Early adopters represent a bridge between innovators and the early majority. The early majority in return provides an interconnectedness in the system between people with high and low acceptance / threshold of the technology.

The early majority follows the leaders and requires some time to adjust to new technology, having lower adoption skills or resources. The late majority adopts either because of a new social norm or because they have recognized the usefulness of new technology. The behavioral control of these individuals differs in comparison with the early adopters or the early majority: they are aware of their scarce resources and avoid uncertainties when they are making such a decision.

The last group in the diffusion process are the laggards, who are conservative individuals with high resistance to new technologies. They are very cautious about new technology and, normally, they adopt them only when the use of previous technologies has become impossible or more complex than the new ones.

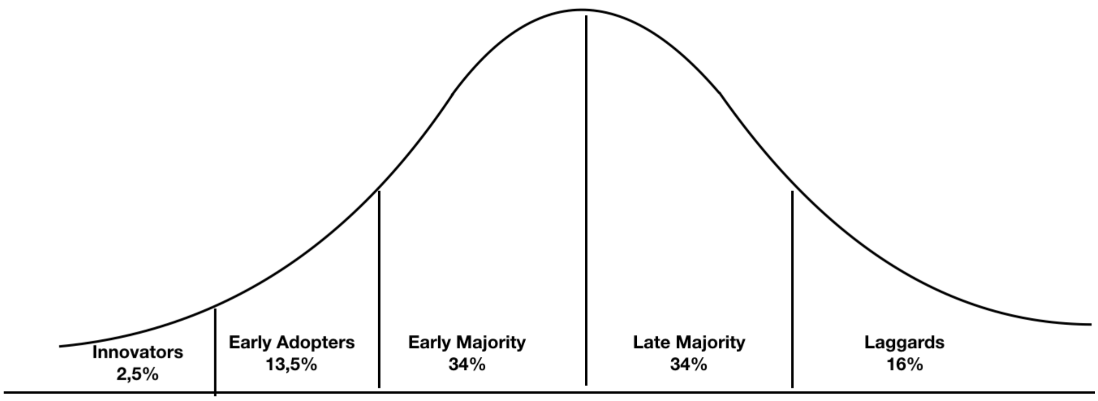


Figure 10: Adoption curve. From DIFFUSION OF INNOVATIONS, 5E by Everett M. Rogers. Copyright © 1995, 2003 by Everett M. Rogers. Copyright © 1962, 1971, 1983 by The Free Press. Reprinted with the permission of The Free Press, a Division of Simon & Schuster, Inc. All rights reserved.

According to this categorization, there are 2.5% of innovators, 13.5% of the early adopters, 34% of the early majority, 34% of the late majority and 16% of laggards on the market (Rogers, 1989, p.247). Critical mass occurs when 10 to 20% of adoption is reached. This appears in the segment between early adopters and the

early majority on the market. For the purpose of this research, critical mass will be defined as a threshold that should be higher than 10% of the market share.
The process of achieving critical mass for startups is not a straightforward one, since time and market chasms can build a barrier that is hard to predict.

3.2.2 Chasm as an obstacle on the way to critical mass

In 2015, the Focus Group on “Mainstreaming Precision Farming”, created by the European Innovation Partnership “Agricultural Productivity and Sustainability” (EIP-AGRI), have admitted that the adoption of a precision farming system is currently lagging. 19 experts from the focus group came to the conclusion that “risk, the initial investment required and insufficient knowledge appear to be the main reasons why farmers do not switch to precision farming” (EIP-AGRI, 2015, p.7).

Moore (1999) explains that the phenomenon of non-adoption appears when the early majority has a much higher threshold for innovation acceptance than early adopters: “Being the first, they [early adopters] also are prepared to bear with the inevitable bugs and glitches that accompany any innovation just coming to market. By contrast, the early majority want to buy a productivity improvement for existing operations. They are looking to minimize the discontinuity with the old ways. They want evolution, not revolution” (Moore, 1999, p.15). This means that critical mass cannot be achieved if the differences between intentions and abilities of the early adopters are drastically different in comparison to the early majority.

According to von Jeinsen *et al.* (2018), who categorized the results of a number of studies, the difference between early adopters and the early majority regarding innovation acceptance in the field of agriculture can be attributed to age, experience, gender and educational level. A number of studies revealed that younger farmers with experience and a higher educational level, were more advanced adopters of new technologies in comparison to their peers (Aguilar-Gallegos *et al.*, 2015; Cavallo *et al.*, 2014). The problem of aging is one of the important issues on the agricultural market. According to the report of the FAO (2014), the average age of farmers in the United States and other developed countries is approximately 60 years. In Africa, where most of the population is under 24, a farmer's average age is also around 60 years. The main difference between young and elderly people concerning technology use is that for the younger farmers, the use of smartphones and tablets is something that they know very well from their private lives, whereas elderly farmers must often learn to use these technologies before they are able to add them to their work processes.

Another important determinant was the size of a farm and, connected with this, the level of income. The more resources a farm has, the more innovative it is (von Jeinsen *et al.*, 2018). To better understand one of the possible reasons that could cause the chasm on the market, it is necessary to define the early adopters and early majority. Starting in the year 2000, there were a number of studies that looked at the acceptance of information and communication technologies (ICT) among farmers in developed countries.

In the research presented here, at first only the European market will be considered for a comparative analysis of the characteristics of early adopters and the early majority. To find relevant studies on ICT adoption, the following scientific databases were used: Google Scholar, science direct, Jstore, Econis, AgEcon. The following keywords were used to select the studies: "technology adoption", "ICT", "IT", "agriculture", "farmers", "precision farming", "smartphone use", "technology diffusion", "Europe". As a result, nine studies were identified that are presented in Table 3 below.

According to the results of the studies presented below, age and the size of the farms play an important role in the adoption of a new technology. Farmers who were younger then 45 years were mentioned as technology-savvy users in the studies. If the share of young farmers on the market is small, and they represent less than 10% of the market, this could be a possible reason for the existence of the chasm. However, what was more important than age was IT literacy and the general educational level. If the market share of farmers who have knowledge and experience with technology for on-farm processes is also small, then this could cause the chasm as well. Another important group of early adopters were large farms that own more than 250 ha. Here, the difference to small and medium-sized farms could primarily be the size of the budget that they can spend on technology, as well as their previous experience with innovations.

Characteristics of ICT early adopters	Characteristics of ICT early majority	Authors of study and year	Country of study
young farm managers with higher education	"older less educated peers"	Stricker *et al.* (2003)	Germany
very large farms, advanced skills	small and medium farms, older farmers	Warren (2004)	United Kingdom
larger farms (more than 300 ha), younger generation (20-29 years old),familiar with the technology	older generation (50-59 years old), smaller farms, lacking technological knowledge	Fountas *et al.* (2005).	United Kingdom, U.S. and Denmark
large farms (between 250-380 ha), better educated (university degree)	small and medium sized farms	Reichardt *et al*. (2009)	Germany
middle age (36-45 years old), educated, male, familiar with ICT, higher income	older, less educated farmers with lower income	Michailidis *et al.* (2008)	Greece
young farmers (< 40 years), higher education, large farms (> 300 ha)	middle aged, medium-sized cultivated land	Lencsés *et al.* (2014)	Hungary
large farms	smaller farms	Steeneveld *et al.* (2015)	Netherlands
full-time farmers, large farms (> 500 ha) with external employees / young or well-educated experienced farmers	part-time farmers, small farms (1-99 ha), family employees	Paustian and Theuvsen (2016)	Germany
good IT knowledge, intention to increase production*	low IT literacy, budgeting problems	Lima *et al.* (2018)	United Kingdom

*The study did not find a definite connection between age or farm size. However, the participants of the survey had a field size of 500 ha, which is larger than the average field size in the UK. 57% of the survey participants were between 46 and 55 years old

Table 3: Characteristics of early adopters and early majority of ICT in agriculture

In addition to the demographic and social aspects of the early adopters and early majority, Ram and Sheth (1989) identified two further reasons for potential customer resistance to innovations: functional and psychological. Functional barriers can be product usage, value and risks. A usage barrier appears when the innovation is not compatible with existing practices, habits and routines. The value of the innovation is defined by its level of usefulness and price performance ratio.

The last technological barrier is risk, which is directly connected with the level of uncertainty and perceived side effects that might appear after starting to implement an innovation. There are four different types of risks connected to innovation: physical, economic, functional and social (Ram and Sheth, 1989). According to EIP-AGRI (2015), in Europe, new agricultural information technologies are connected more closely with functional risks, meaning users are not sure about the performance of the technology and economic risks if a certain amount of investment is needed.

Psychological barriers include cultural and traditional as well as image barriers. Cultural and traditional barriers change very slowly and are connected with the social acceptability of certain innovations. Image barriers represent the consumer's associations with the innovation or its producers. If a manufacturer that has an otherwise bad reputation launches a potentially useful innovation, it could be met with resistance by potential customers.

Some functional and psychological barriers on the way to adoption could be explained by the immaturity of the technology. This means that startups sometimes bring technologies to the market that cannot be employed immediately for various reasons, e.g. lack of suitable infrastructure, legislation or the weakness of the technology itself.

3.2.3 Technology maturity and its impact on critical mass

The topic of technology maturity measurement is almost as old as the diffusion of innovation itself. The maturity of the technology is a basis for the achievement of critical mass. Albert (2015) delineated four types of existing systems for technology maturity measurements: theoretical, semi-theoretical, semi-operationalized and operationalized.

Theoretical models suggest ambiguous methods for the measurement of technology development without specific measurable indicators. As an example, Albert (2015) suggests Gartner's Hype Cycle model. This model was developed in

1995 by an American research and advisory company, Gartner, and explains the spread of hype through the media and its importance for technology adoption. Media hype in this sense could be described as a process where “an (unusual) event triggers increased media attention; the media set their focus on this specific topic or event; they enlarge it, and by so doing evoke all kinds of social responses, which will in turn become news as well, further stimulating the news wave” (Vasterman, 2005). Mass media sometimes embraces new technology and describes it as a break-through too early. This information gives hope and spurs the creation of new ventures using this technology. However, oftentimes such new ventures fail without achieving proof of concept because the costs of the technology are high, and the benefits are not clear. Later, disillusion displaces the hype (Linden and Fenn, 2003).

The problem with hype is that the media describes an innovation as more mature than it really is. At the same time, experience and knowledge that was gathered in times of hype helps to create new improved generations of the technology, which creates a basis for mainstream adoption. An important question for any innovative company is: How to understand when there is hype on the market and when the technology is mature enough to be implemented? According to the report by Linden and Fenn (2003), hype starts at an early stage of technological development, and its peak is achieved when, on the market, there is almost no adoption at first because the technology’s performance is poor. When the hype ends, usually there are already new generations of the technology on the market. The ecosystem for this technology starts to evolve and, with it, adoption starts to increase. The maturity of technology starts when more than 30% of potential customers have adopted the technology. For better understanding the graph below shows the Gartner Hype Circle combined with the Rogers adoption curve (Figure 11).

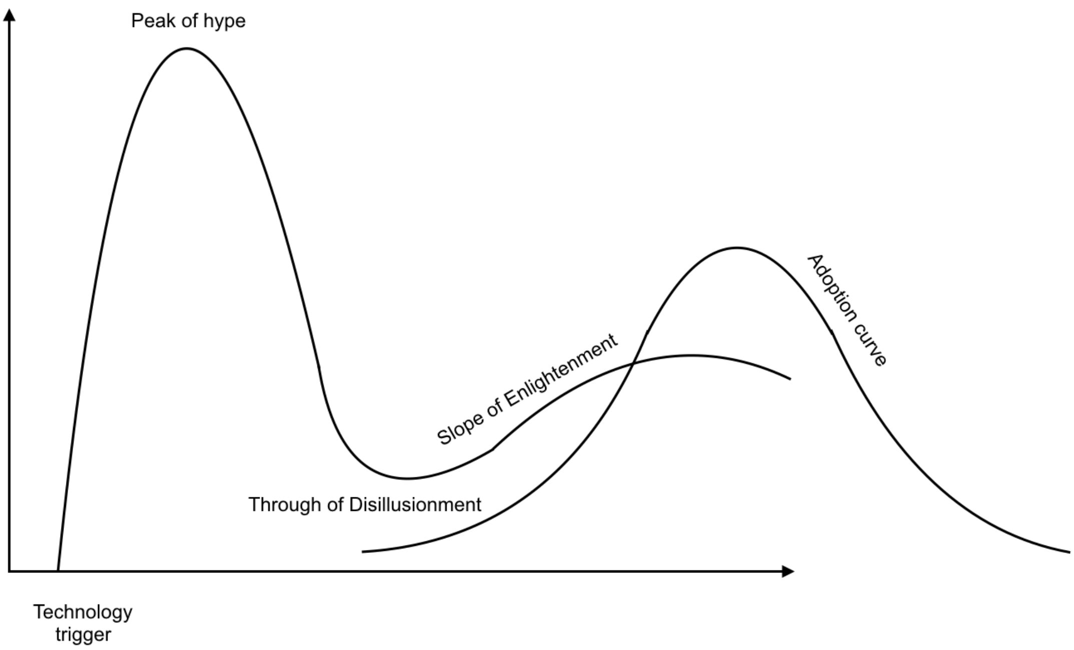


Figure 11: Gartner Hype Cycle (adopted from Linden and Fenn, 2003) and Adoption Curve (adopted from Rogers, 1983)

Based on the Gartner Hype Cycle, Monsanto has developed their own vision of the current maturity state for existing agricultural innovations (Jarolímek *et al.*, 2017, p.70). In the following paragraphs, along with the description of each phase of the Gartner Hype Cycle, the maturity level of these agricultural innovations will be mentioned.

The first phase of an innovation trigger starts with the first press releases and technology demonstrations, which attract even more attention to it. However, there is no usable product at the time. Then, an “on the rise” stage occurs, which stands between the trigger and peak of the hype. During this stage, there are many explanatory and discussion articles about the technology; first, highly specialized products or extremely hard-to-use products appear on the market. Regarding agriculture, according to the Monsanto corporation, such technologies as indoor farming, on-plant sensors and in-field wireless are still on the rise (Jarolímek *et al.*, 2017, p.70). For the products at this stage, the prices are normally very high, as the developers hope to regain their investment. Alternatively, they are just too complex and cannot really offer a relative advantage.

At the “peak of hype” stage, the number of startups increases, and they try to use the hype for their marketing purposes and to obtain investment. However, at this stage, the technology is still not suitable for use even by early adopters. Since there are more new products that are not mature enough, the first negative press articles appear. Less interest from the media leads to disillusionment, which characterizes the stage of “the Trough of Disillusionment”. Currently, in the eyes of Monsanto, aerial imagery and big data in the field of agriculture are currently in the disillusionment phase (Jarolímek *et al.*, 2017, p.70). At the following stage, “Slope of Enlightenment”, more companies appear that offer improved versions of the technology. They are more willing to experiment and to test their solutions. Early adopters start actively using the innovation. At the beginning of this stage, the product penetration is less than 5%. In the end, it ends up taking 30% of the market. In this phase, according to Monsanto, farm management systems and satellite imagery can be taken as examples (Jarolímek *et al.*, 2017, p.70).

“The Plateau of Productivity” is the beginning of the introduction of the product to the mainstream market, where the technology starts to be integrated into other products; services around this technology appear. Yield monitors, soil sampling, in-cab displays and auto-steer are close to becoming mainstream products and could be applied by the majority of farmers, according to Monsanto’s estimates (Jarolímek *et al.*, 2017, p.70). Consistent with this theoretical model, critical mass could be achieved when an innovation is at the stage of the “Slope of Enlightenment”.

Semi-theoretical models, in contrast to the theoretical ones, provide other feasible factors that could be measured. However, these factors do not always have measurable indicators, which reduces their applicability. As an example of such measurement systems, Albert (2015) presented a model of Sommerlatte and Deschamps (1986), which describes the different stages of technology development. The model was selected by Albert (2015) because of its popularity and good description of technology maturity stages. Sommerlatte and Deschamps (1986) divided technology development processes into four stages: emergence, growth, saturation and decline. To be able to define a current state of a technology, the authors suggest following indicators: insecurity of technological performance, level of investment in the technology, number of technology applications, type of development requirements, impact on cost or performance of products, number and type of patents, access requirements, and availability of technology (Sommerlatte and Deschamps, 1986).

For example, during the growth phase of innovation technological performance is moderate; the level of investment is maximal; the number of cases of technology use increases; the development of innovation is aimed at the creation of new use cases; the impact on cost or performance is maximal; the number of patents is high; and most of them are product-oriented; the access to a product is given to the personnel of a company who then act as early adopters; and its availability is amplifying (Albert, 2015). Sommerlatte and Deschamps (1986) also use an increasing number of case studies as an indicator for the growth stage.

As examples of **semi-operationalized models,** Albert (2015) indicates the S-curve, which was used by Foster (1986), the Technology Readiness Level (TRL), as suggested in the NASA White Paper by Mankins (1995), and patent-based models.

Foster (1986) suggested a measurement of technological maturity according to its returns on investment that resemble the S-curve Pattern of Innovation. In the very beginning of a technology's development, there is either low or no return on investment. With further development of the technology, the occurrence of a large positive difference between previous and current periods could be a sign of technological maturity in terms of return on investment. When the return on investment starts to stagnate or even decline, it is a sign that the current technology already has achieved its full potential.

The TRL method was suggested as a method for estimation of the readiness of space technology. This method has nine stages that could be divided into four groups: ideation, development, prototype testing and testing in the real context. When the prototype is successfully tested in a real context, this is an indicator for the maturity of the technology.

The third instrument of semi-operationalized technology maturity measurement Albert mentions is the consideration of the number of patents and/or number of licenses and/or royalties. Basberg (1987) argues in favor of patent measurement because patent statistics are available and provide data that allow making cross-industrial and cross-national comparisons and to observe the diffusion of innovation among countries. Haupt *et al.* (2007) are in favor of this method because obtaining patents gives companies an opportunity to commercialize the patented invention. According to the results of their study, for one particular technology, the number of literature citations and citations of other patents in the same technological field increases significantly during the transitional phase from technology emergence to its growth phase. Also, the time taken/needed to examine a new patent is shorter during the growth period in comparison to the introduction and maturity period (Haupt *et al.*, 2007).

The last type of technology maturity measurement method consists of **operationalized models** that, according to Albert (2015), are very rare. One such model is suggested by Watts and Porter (1997). The core method of this model is monitoring bibliographic sources about a certain technology to find out "who is doing what now?". One of the ways is to look at a specific scientific database and monitor hits or ratings of articles about this technology. For this purpose, special keywords about the technology are usually selected. Searching these keywords in the abstracts of scientific articles should give an impression about the direction of research in this area and the number of articles written about it. To observe technology development, it is necessary to monitor the number of articles that appear in the fundamental research, in the applied research, and in the evidence or impact measurement research. When the technology is in its early stages, the number of articles will be the highest in the fundamental research area. Then, with the development of the technology, this number will decline, and the number of research articles about the technology's application will increase.

This approach was amplified in the concept of the Technology Life Cycle (TLC). This system takes into consideration several sources of information, e.g. science citation indexes, engineering indexes, patent information and newspapers, which can help estimate the social impact of an innovation. The most important aspect of the TLC model is that the increasing number of mentions of the technology in various sources should be sequential. This means that first mentions of a new technology should be found in scientific literature, then in the literature regarding application (engineering), then in patent information sources and only then in the press.

One of the criticisms of the bibliographic method is that often, in technological forecasting, only one database is used and not several at the same time. Such a selection can lead to a biased perspective on technological development (Järvenpää *et al.,* 2011). The first two sources of information – science and engineering research – are usually obtained from the two largest databases (such as the Science Citation Index and Compendex), and other sources of information are not considered. Using patent information could also, in some technological cases, be disadvantageous, because some technologies that appear on the market are not patentable (like open-source technologies, for example), and some technologies that were patented were never commercialized. Järvenpää *et al*. (2011) selected three different technologies and tested the TLC model; only the development of one technology followed the sequential order of the TLC model.

Since there is no perfect model that can help detect the exact stage of innovation development, this could be an interesting topic for further research. For the purposes of the research presented here, the results of the hype cycle developed by Monsanto will be taken into consideration, and agricultural technologies that are in the phase of the "Slope of Enlightenment" or further will be selected for the qualitative investigation, because these are the phases where critical mass takes place (see Figure 11) .

To gain a better understanding of the current situation on the agricultural market, the following questions must be asked: What kinds of barriers do startups see on the way to achievement of critical mass? What kinds of strategies do they use to grow and to gain the acceptance of farmers? To provide suitable answers, a qualitative investigation shall first be conducted.

4 Explorative study of the market perception and current marketing strategies of agricultural startups

Currently there are several challenges for growth due to the demographical and social changes on the agricultural market, as delineated in the previous chapter. To understand which strategies can support startups in overcoming these challenges that eventually cause chasms on the market, and help them achieve critical mass, it is necessary to look at the current strategies that startups use. It is also becoming necessary to select the most promising ones. To do so, the existing startup strategies used in developed and developing countries will be explored. The exploration of these strategies will be conducted with the use of the qualitative method.

4.1 The qualitative method and its role in agricultural research

Qualitative research could be described as "any type of research that produces findings not arrived at by statistical procedures or other means of quantification" (Strauss and Corbin, 1998, pp.10-11). Although agricultural economics is a part of social science, in contrast to other social sciences such as communication, ethnology or sociology, the use of the qualitative method is relatively rare, except in studies regarding agricultural economics in developing countries (Bitsch, 2000). In 1950, the percentage of studies using quantitative methods was, as mentioned in the "American Journal of Agricultural Economics", only 5%. It rose to 92% in 1992 (Bitsch, 2001). Nonetheless, the qualitative method is usually a part of any research where the research subject is abstract or complex. A complex subject, such as technology adoption or crossing the chasm, became popular within agricultural research and, as a result, a number of studies that used qualitative methods were published (Sattar *et al.*, 2017).

Technology adoption research includes several complex topics, such as farmers' behavior and perceptions, socio-economic factors, communication (the spread of information), psychological factors, and institutional aspects. The scientific approach for research on complex subjects is defined by the choice of the research method. In the introduction, it was already mentioned that, for the research presented here, a post-positivism paradigm was selected. Therefore, the findings of this research might not be directly generalized because post-positivism recognizes the uniqueness of situations or culture, but they could be transferable to other contexts (O'Leary, 2004).

The contribution of qualitative research consists of providing answers to open-end questions like "why" and "how" (Ritchie and Lewis, 2003). In this case, the present analysis seeks insight into how digital agricultural startups manage to grow on the agricultural market. To reach this objective, the method selected was that of the in-depth interview.

4.1.1 Role of the in-depth interview in the investigation process

An interview could be defined as a process where the knowledge emerges through the collaboration between interviewee and researcher (Holstein and Gubrium, 1997). Qualitative methodology demands that the researcher be a good listener and have a flexible and clear mind to be able to react quickly to conversational developments (Legard *et al.*, 2003). Usually, in-depth interviews include a small number of respondents to investigate their perspective on a certain topic (Boyce and Neale, 2006). In-depth interviews are, most of the time, semi-structured, containing guidelines that support flexibility during the interview. If the interviewee's answer spontaneously raises an issue or topic not previously included in the interview guide, then it is still possible to explore this topic. According to Stokes and Bergin (2006) there are several advantages of the in-depth interview:

1) An in-depth interview is more detailed than surveys;
2) In-depth interviews provide comprehensiveness of information. The researcher has an opportunity to obtain necessary information using two approaches: exploration or explanation. Often, certain answers could be superficial or lacking logical sequence. In that case, there is an opportunity to clarify the information via follow-up questions.
3) The researcher has an opportunity to observe the emotions and reactions of the interviewee during the interview, which could confirm or disprove certain

assumptions.

The advantages of this method help achieve the aim of this study, i.e. to investigate a startup's approach to growth and gain a better insight into how the digital agricultural market works. The unstructured survey provides an opportunity to diverge a number of possible strategies to cross the chasm (the gap between early adopters and early majority), which will later be converged to a number of strategies for establishing a concrete hypothesis.

In choosing the number of the in-depth interviews needed to represent an overall picture of the phenomenon, the data saturation method will be used. Data saturation could be comparable to sample significance in the quantitative method. Data saturation is a point during the analysis of the data where, with each new interview conducted with the same target group, no new information or themes are disclosed (Bowen, 2008). When data saturation is achieved, it can be assumed that the existing sample is substantial enough to detect certain patterns.

4.1.2 Triangulation as a verification method for qualitative data

To verify the results from the in-depth interviews and to be able to elaborate a theoretical framework, a data triangulation method will be used. "Triangulation means looking at the same phenomenon, or research question, from more than one source of data" (Decrop, 1999, p.158). Data triangulation, on the one hand, helps one understand whether the findings contradict or support the existing results of previous studies (Miles and Huberman, 1984). On the other hand, data triangulation helps to discover additional topical insights that were found in other studies or theories. This helps to amplify the understanding of the phenomena and the design of further research.

According to the scientific literature, it is possible to identify four different types of triangulation: „Triangulation of data combines data drawn from different sources and different times, in different places from different people" (Flick, 2004, p.178). There are two methods of performing data triangulation: 1) the use of secondary data (photographs, articles, statistical data, films, etc.) beyond the primary material, such as interviews or observations; 2) field notes that are taken immediately after observation or interview, for example (Decrop, 1999). Data triangulation is helpful to understand, for one, if the research subject behaves the same in the different situations, in different places or at a different time of day.

Triangulation of theories is defined as „approaching data with multiple perspectives and hypotheses in mind… Various theoretical points of view could be placed side by side to assess their utility and power“ (Denzin, 2009, p.303).

Method triangulation consists of using a combination of methods for researching the same object. It could be a combination of the quantitative and the qualitative methods, but not in hierarchical way. Such an approach can help reduce the biases and limits of each method (Decrop, 1999).

The fourth type of triangulation is investigator triangulation, which “is characterized by the use of different observers or interviewers, to balance out subjective influences of individuals“ (Flick, 2004, p.178).

4.2 Data collection and analysis of the in-depth interviews

The following criteria were applied to select digital agricultural startups for the in-depth interviews: 1) the startup's website is online and its product or working prototype is ready to be tested or is already being used; 2) the product or solution has been built based on information technology; 3) the product or a solution is scalable; 4) farmers are the target group of the startup. To find such startups, the two largest platforms that provide information about startups worldwide were used: f6s and AngelList. In addition to these two platforms, contacts to startups obtained during the Agritechnica fair in Hannover in 2015 and the GIL (full name of the initiator of the conference in German “Gesellschaft für Informatik in der Land-, Forst- und Ernährungswirtschaft e.V.”) conference in 2016 were used. All in all, 19 startups were contacted: 10 startups from developed countries including such countries as the USA, Germany, Austria, Australia, the Netherlands and the United Kingdom; and 9 startups from developing countries such as India, Indonesia, the

Philippines, the Ukraine, Israel, Tanzania and Nigeria. 11 of them agreed to participate in the interviews. Each interview lasted between 40 and 70 minutes. To better structure the in-depth interviews, a guideline questionnaire with open questions was prepared. The questionnaire contained questions about the founders, product development, early adopters and the startup's network. Most of the interviews were recorded via Skype conversations. Each interview was then transcribed on the same day. Table 4 showcases the information gleaned from the startups interviewed.

Type of country*	Country	Interviewees' role	Interviewee 's abbreviation	Product phase	Business field
DEVELOPED	Germany	co-founder	I4	in development	farm management system
	Germany	managing director	I1	developed and tested	asparagus monitoring
	Germany	founder	I7	on the market	farm management system
	Germany	co-founder	I10	on the market	plant disease diagnostic app
	Australia	co-founder	I11	on the market	farm management system
DEVELOPING	Israel	business development manager	I3	on the market	pest management software
	Ukraine	co-founder	I2	on the market	navigation and documentation solutions
	India	co-founder	I8	on the market	e-commerce
	Indonesia	co-founder	I9	on the market	e-commerce
	Philippines	founder	I6	in development	crowdfunding for farmers
	Tanzania	co-founder	I5	on the market	e-commerce

*Country division according to "developed" and "developing" is based on the report of the United Nations (2014)

Table 4: Overview of the digital agricultural startups interviewed

In the case of the research presented here, the 11 interviews took place over two months. The number of the interviewee's abbreviation is the corresponding number in the sequence of the interviews. I 1 was the first startup that was interviewed, followed by I 2, I 3, etc.. After each interview, there was an at least two-day-long break to analyze the interview, to code the interviewee's perception of his/her startup's growth, to categorize and to summarize it for ensuing analysis. 11 interviews were enough to achieve data saturation because there were no new novel insights[3] gained during the last three interviews (Guest *et al.*, 2006, p.68).

To analyze the data obtained from the in-depth interviews, the coding method was used. "A code in qualitative inquiry is most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data" (Saldaña, 2009, p.3). The type of coding used in this work was a descriptive code. This type of coding summarizes, with one or two words, a sense of one or more sentences within the data. This type of code is especially helpful during the initial round of coding to get a first impression of the data collected and its content. The aim of a coding process is to detect patterns in the qualitative data. In the case of the research presented here, the similar patterns in the growth perceptions of the founders were explored.

To spot the patterns, it is necessary to perform several cycles of coding and categorizing the data obtained. To make the coding process more efficient and structured, a Computer Assisted Data Analysis Software (CAQDAS) is normally used. There are three software programs most often used to analyze qualitative data: ATLAS.ti, MAXQDA and NVivo (Saldaña, 2009).

For the analysis of the data from the present in-depth interviews, ATLAS.ti. (Version 8.2.4 (559))[4] was utilized. In the scientific literature, it is possible to find a software guide for ATLAS.ti (Friese, 2014), as well as several case studies of the software's use (Hwang, 2008). This software has already been used in the area of agriculture, for example, for learning about farmers' beliefs in Austria, Cuba and Israel regarding the trial of something new on their organic farms (Leitgeb *et al.*,

[3] No new codes were gained in the last three interviews

[4] ATLAS.ti Scientific Software Development GmbH

2011) or the adoption of web-based spatial tools by agricultural producers (Jarvis *et al.,* 2017). For the purpose of this research, ATLAS.ti helped to structurally analyze qualitative data, identify connections between the interviews, and to keep records of the observations during the analysis.

The interviews were, at first, manually transcribed and imported to the qualitative data analysis software ATLAS.ti. The results of the interviews come from five rounds of coding, where the categories were rearranged three times and the resulting data was compared. The first round of coding provided a general impression of the interviews and numerous initial assumptions; the following rounds sought to converge the initial assumptions in all the interviews into a set of core assumptions which were mentioned by most interviewees. In the first round, there were 31 categories that described the main assumptions[5] made by the interviewees. Among those assumptions were such categories as business model, family and friends, and early adopters' or cofounders' motivation. In the following rounds, those categories were rearranged and condensed to seven main patterns. Each of the seven categories represents a description of a startup's perspective of the situation on the agricultural market, its target group, its growth and the challenges it faces. These seven patterns are: 1) low frequency of the IT solution use (due to high costs, little competition or technology scarcity); 2) the difficulty to demonstrate the results of the solution; 3) lack of trust due to newness of the company; 4) the importance of joint development with customers; 5) mass media as a contributor to fast growth; 6) interpersonal communication as the most effective communication channel; 7) cooperation regarding education and distribution as a scalable model for interpersonal communication. To provide a better overview of the results, these seven patterns were divided into two major groups: obstacles on the market and marketing strategies.

To verify the patterns obtained from the interviews, the data triangulation method was used. To compare the results of the interviews, other existing studies and information published by farmers in the forums and app stores were taken into account.

[5] The codes are presented in Annex 8.2

To carry out the data triangulation, statistical data and relevant studies that were made in the past 10 years were selected (from 2007 till 2017). For the study search, the following scientific data bases were used: Google Scholar, science direct, Jstore, Econis, AgEcon. As a result, more than 50 studies and statistical sources were reviewed. Furthermore, 23 additional sources were selected, such as interviews conducted by third parties with some of the startup-founders who participated in the current in-depth interviews, and published in online media such as blogs, magazines and newspapers; comments of users in forums and app stores concerning the products that startups presented on the market. Those comments were found on such forums as “the digitalfarmer”, “agrowissen”, “thefarmingforum”, “id.techasia”, and on Google Play. This data concerned 9 out of 11 of the startups interviewed. Two of the startups also enjoy a definite presence in the press. However, the information presented in those sources had a generally descriptive character about a service or the startup itself.

4.3 Results of the in-depth interviews

4.3.1 Market obstacles on the agricultural market from the startup perspective

The analysis of the in-depth interviews revealed three main obstacles on the market, which most of the startups interviewed mentioned: low frequency of the IT solution use, the difficulty to scale the demonstration of the results and lack of trust due to newness of the company. The assumptions made by the startups during the interviews that underline these selected barriers are presented below in Table 5.

One of the common assumptions made by the startups interviewed concerned the low frequency of IT solutions used among farmers. The quotes represented below (Table 5) reveal three main explanations of that phenomena. One possible explanation is that there are not many competitors within the online IT solutions sector. In the developing countries there is an additional challenge that makes the spread of the technology more difficult: restricted access to the Internet and/or scarcity of mobile devices. The third possible explanation to the low frequency of IT use of is the high price of the new high-tech equipment.

The second obstacle to growth on the market appeared due to issues with the scalability of the results demonstrability. As mentioned in several quotes in Table 5, the technology was stated to be used only if neighbors are also using it. However, the adoption of the technology does not spread further and remains a “hot-spot” in certain regions.

The last obstacle is the company’s newness on the market. Farmers are often skeptical about the company and the solution that it offers because, independently of how good it is, if something goes wrong and the company does not exist anymore, it is unclear who should help solve the problem and update the solution. The feeling of the security according to a quote represented below is sometimes more important than certain software features or the software itself.

Table 5 presents the corresponding quotes from the interviews which underline the importance of a certain obstacle.

Market obstacles	**Quote from the interviews**
low frequency of the IT solution use	“…we looked at what competitors were doing and wanted to undercut them. But that's said, the competitors are no really competitors, because there is so little usage of the software in the space. I mean our biggest competitor is pencil and paper.”- [I11] “when we started in 2006-2007 there were no software competitors in the agricultural market in Ukraine. We have recognised that there was a huge potential and a lot of space for experimenting.” - [I2] “There are 34 millions of tractors and only say one million has some navigation systems which help during daily operations. However, this navigation system only few farmers can afford. These farmers are usually rich or very well familiar with the technology or both at the same time. Most farmers can not afford this type of the system. Because they are usually too expensive or too complicated or both.” - [I2]

Market obstacles	Quote from the interviews
low scalability of results demonstrability	"When I go to California to sell to a customer. They care very little for me telling them "you know I have this great organisation in Israel, you know who works with me", because they do not care. But if I tell them you know Tom from Napa valley and Mike from central Valley and this guy from that winery they are very happy with our product so go there and talk to them." - [I3] "We are looking on the map of our users und see there kind of hot spots. Usually first appears one red dot that symbolises our first user who started using our product and then some time later we see how his neighbours also starting using our product. Such kind of hot spots is a normal picture of how we gain new customers." - [I2] "What we currently see is that there are popping up hot spot. Probably young people show their fathers or older generation in their companies that they want to use different tools, and probably then those who saw it share it further with their friends and those start working with it." - [I7]
lack of trust due to the newness on the market	"One of the biggest changes is the name recognition. Now when we go to the trade shows everyone heard of us and people have seen our ads, and people have seen our tweets and be sort of now have this name recognition that we did not have last year. And that is really important because trust that the company is going continue to exist is really important. In the early days we often had people saying "no" to us because they said "I wanna see if you going be around in six months because I do not want invest in something like this if you going fail." - [I11] "Because clients need to understand that what we offer is more than just a software and they usually understand it. They see that this is a team and if something is going to break we will help to repair it. It is a certain level of security, for our clients it is important to know that we are not going to disappear tomorrow from the market, that we already exist for a while and we are going to stay on the market." - [I2]

Table 5: Quotes made by the digital agricultural startups interviewed regarding market obstacles

4.3.2 Data triangulation: the market obstacles

The three challenges that startups identified as their main barriers to growth – the low frequency of IT solution use (due to high costs, low level of competition or technology scarcity), the difficulty to scale the demonstrability of the solution's results and the lack of trust (caused by the company's newness) – will be triangulated with the farmers' opinions (those who were using the solution or considering doing so) as well as agricultural studies on this topic.

In an interview with the Australian "Stock journal", one of the farmers who reported about the technology use on his farm and especially about the product of [I11]', underlined that "critical to the success will be good farm software packages that are intuitive" (Miller, 2017).

Beyond the ease of use, the customers of the startups interviewed are also concerned about another problem that was not named by the interviewees: compatibility of their technology with existing ones. One farmer who considered using the solution of [I11] mentioned on the "the digital farmer" forum in 2015: "Tired of every application running just one segment of my farm." This problem was also mentioned by another farmer at the same forum. Although the farm is small, the owners run copious amounts of documentation. Having one solution for this documentation is important.[6]

Cost as a barrier was also mentioned by the farmers who were considering use of the [I2] solution. In this quote from the "landwirt.com" forum, a participant wrote, on January 17, 2018, at 12:09 pm, the following about his purchase decision [translation from German] "Here are the advantages that, for me, were decisive for purchasing this product: 1) I could easily just purchase a tablet instead of an expensive computer; 2) no fees for signal corrections that are automatically generated through the station (radius 10 km); 3) 100 EUR for a software maintenance license, which is constantly further developed (meanwhile, to use the software of other companies you need to buy a new computer after a certain

[6] The review to the product of the interviewed startup http://www.thedigitalfarmer.com.au/product/agriwebb-notebook (04.08.2019)

period of time)."[7]

Although the startups interviewed are aware of the price problem and are offering cheaper solutions in comparison to existing companies, the advantages offered are still insufficient. Here is a quote from the forum on the "landwirt.com" website from January 7, 2018 about the solution offered by startup [I2]: "For my small farm, the solution unfortunately is not economically viable, even though the price in comparison to other companies is low."[8]

The infrequent use of the online applications for farmers in the developing countries has additional dimensions, such as a lack of infrastructure or mobile technology that allows internet use (like a smartphone or a tablet). One of the co-founders of the Indonesian startup, [I9], mentioned infrequent use of the technology due to non-availability of smartphones (translated from Indonesian): "Supply depends on the number of farmers who want to use our application to sell their products, but farmers rarely use smartphones and applications." (Viva, 2017)

The difficulty of using the online solution by the Tanzanian startup lies in the general scarcity of smartphones, as confirmed a study conducted by Mwakaje (2010). According to the study's results, the use of ICT is constrained by costs, accessibility, and reliability. A large number of respondents (68%) said that they did not have the money to buy the ICT facilities or services.

However, even in a developed country like Germany, the advantages of Internet solutions for smartphones or tablets are not necessarily being used by the majority of farmers. In 2013, the latest study of agriMA (readers' analysis of the newspapers's market for the agricultural sector) revealed that more than 52% of farmers surveyed in Germany use the Internet for their business every day, although only a few farmers use a smartphone for their business activities. Mostly, farmers do not use a specific software or device to manage their business

---

7 The link to the original comment: https://www.landwirt.com/Forum/551698/efarmer-GPS.html (04.08.2019)

8 The link to the original comment: https://www.landwirt.com/Forum/551698/efarmer-GPS.html (04.08.2019)

processes, but weather apps, text messages or news bulletins.

The last obstacle mentioned by the startups was a lack of trust. A positive perception of a company and trust in its services or products by its customers is the basis for customer loyalty and word-of-mouth (Seja, 2012). In the interview with the blog “Samfloy”, the founder of startup [I5] again mentioned the importance of trust: “Similar to anything that involves a behavior change, people need to be able to trust what they’re doing. We need to make sure that farmers and buyers feel that they can rely on the [I5] platform” (Floy, 2017).

There are several studies that explored the question of the importance of trust in technology adoption within the agricultural field. Chi and Yamada (2002) discovered that, among the most important factors affecting farmers’ opinions regarding farming system technologies in Vietnam, were trust in the respective technicians as well as result demonstrability. Another study which was conducted in Greece, Italy and Turkey through in-depth, face-to-face interviews and focus groups with different players from the agricultural sector (e.g. technology providers, farm co-ops, researchers, medium-sized and large farms) showed that there is some distrust, especially if the farmer does not have enough experience with the technology (Pignatti *et al.*, 2015). The authors of the study discovered that “in-field demonstrations, pilot farms and farmers, along with successful experiences of technological innovations’ implementation, could fasten the process of awareness and trust raising, and seem to be the most convincing reason to adopt innovations and spread them among end-users” (Pignatti *et al.*, 2015, p.79).

According to the results of the in-depth interviews and the data triangulation, such obstacles as price, lack of trust and not obvious benefits of the technology represent one group of the factors why farmers are unwilling to use a new technology. Additionally farmers named the ease of use and compatibility of the technology as important determinants in the decision-making process. These factors were not mentioned by the startups but came from the comments of the potential users.

In the developing countries insufficient infrastructure and low frequency of smartphone use were also verified by the studies and further interviews with the startups that took part in the research presented here.

4.3.3 Marketing strategies to achieve growth on the agricultural market

According to the interviews it was possible to determine four major marketing strategies that agricultural startups apply to achieve growth on the market. The first was user-oriented product development, the second was use of the mass media, the third was attending events (such as fairs or product presentations) and the last was cooperation with distributors or for educational purposes to overcome growth barriers and build faster trust. The quotes from the interviews that support these findings are presented below in Table 6.

To overcome the risk of infrequent technology use, several startups decided to develop their product along with their potential customers. One of the interviewees affirmed that it does not really matter what kind of product you have; what is important is how the product is developed and how you build the relationship with your users. A couple of startups presented a very basic product with a minimal number of features to get their first users on board. With these users, they started developing a product that was intended to satisfy the needs of a later majority. Thus, even without a fully functional product, some startups managed to build their first audience. After the first prototype demonstration or product release, first the early adopters actively participated in the further product development. Often, the first testers who influenced the development of the solution came from the startup’s family and circle of friends. Such connections were usually used at the starting point for proving the viability of their concept, but not for further growth.

A further strategy that was mentioned by almost all startups interviewed was use of the mass media. Several startups mentioned that articles in agricultural magazines helped them gain new customers. Articles about a product in the daily press helped them gain the attention of potential partners or other journalists.

However, this kind of endorsement works only for a short period of time, according to the in-depth interviews. New customers appear when news about the respective startup has already been published. Later, the growth rate stabilizes and is more or less the same as before the appearance in the press.

Another important channel that works well, according to the startups, is direct contact with farmers. To get directly in touch with farmers, startups attend various events. Some even organize such events to motivate farmers to test their solutions. Many startups presented their product for the first time at fairs. Several startups mentioned that they also use events as an opportunity to establish influential contacts with potential partners who can either become investors or connect them with important customers.

Other strategies for growth that several startups use involve various types of cooperation. All startups face the challenge of expanding their product or service to other countries or regions. To start growing in a new region, a number of agents should be sent there to present the product, as direct contact is the most effective communication channel with farmers, according to the interviews presented here. However, this model does not allow a startup to expand rapidly. A few startups found a solution to this problem through partnering with other companies or non-governmental organizations. The main advantage for the partner in such a cooperation is the additional value for their own services. For startups, the partnership helps overcome trust problems, because those companies often have direct contact with a number of farmers and have built their reputation already.

Such cooperations often have several purposes, among which are distribution and/or education. Cooperations with NGOs or institutions are often used for educational purposes, wherein farmers have an immediate opportunity to test the technology to see how it works and what benefits it can bring. In this sense, these cooperations work as distributors at the same time. Cooperation with companies, in most cases, serves as a pure distributional channel. However, as is the case with one of the startups, a respected corporation can also improve the status of a startup on the market and thus help gain the trust of more potential customers.

The table below presents specific quotes from the interviews that emphasize the marketing strategy patterns among the startups.

Marketing strategies	Quote from the interviews
customer involvement in the product development	"My co-founder had a family farm. And they had farm consultancy they use on their farm and they actually facilitated the introduction to a series of sort of progressive farmers that wanted to get involved and help drive the direction of product. So that's how we got our early adopters/beta testers product development assistance I guess." - [I11]
	"I would say professionally the biggest break through was to get the largest winery in Israel to be our design partner. Once they showed interest in what we are doing we suddenly got access to all their entomologists, growers, agronomists to their entire team. They could give us insights and say like - look this is not going to work, or do not put this button here, because nobody is going to use it, because in the sun you cannot see the reflection." - [I3]
	"In 2012 we published our first app and already in 2015 we had 3000 users. […] Our first product was a standard farm management system, which could be used in any country, but it did not have any special reports or specifications which were necessary in certain countries. That was the moment when we started asking our existing clients what kind of features they need in first place to adjust our product." - [I2]
	"We contacted directly our early adopters, primarily our friends, friends of friends and acquaintances whom we put in a beta-group. We have gathered 100 group-members, who were testing and telling us every time if they do not understand something or something does not work." - [I10]
use of mass media to accelerate growth	"Cross-regional newspapers such as "Handelsblatt" or "Süddeutsche" helped us to gain contacts with enterprises. Specialised magazines bring to us more farmers who start using our platform." - [I7]
	"Everybody knows about our startup, because there was a broad coverage in all news in Indonesia about us. …then the number of downloads multiplied by three times in three days." - [I9]

Marketing strategies	Quote from the interviews
	"…the press was something that got it on. We wrote among other "HAZ" about our app and they found our idea interesting and wrote about us half a page. Thanks to this article on Thursday morning I got a call from NDR and they asked us if we would like to present our app in the program "NDR Mag", which is a TV program for consumers, and we agreed, of course…It was a really good job after it we just observed how fast grew our number of downloads and number of emails." - [I10]
	"Print is also still very alive and well in the space. The results of that have been a dramatic increase in a lead generation." - [I11]
events as a way to gain early adopters	"Agricultural market in Germany is very specific. To find our first customers we went to many different events and presented our product. 80% of our current customers we gained through such events and 20% through word-of-mouth." - [I4]
	"So the first time we really went out sort of to the broader market beyond the personal relationship was in late April of 2015 or mid April of 2015. We went to a small events Sheep Technology days." - [I11]
	"There was summit called Indonesian e-commerce summit and expo in Tangerang. We were invited by the government and we joined. The first day our downloads were 1200 after three days the downloads 2040 and but unfortunately the number of sales stucked it was like previously: 2-3 per day." - [I9]
	"So one of my largest customer that I am taking about came form that trade show. And even came unplanned. I had a great meeting with a potential investor and investor liked us so much that he referred us." - [I3]
	"We were, for example, once invited as a speakers to a conference in Geneva at the United Nations and after the conference though we did not really know who was sitting in the audience, but we received then couple of interesting e-mails and some participants talked to us right after the presentation. That is how we step by step build our contacts." - [I10]
	"We have built a limited edition of the product, which had 100 pieces. All 100 pieces were immediately booked during a fair." - [I1]

Marketing strategies	Quote from the interviews
cooperation	"Our partners are dealers who sell certain IT or connected with IT services. We have many such partners in Hungary, Czech Republic, Lithuania, Brazil and Argentina. There is a great number of such companies. They receive from us an additional product. For example they have a hardware solution for farmers ,for example, from John Deer which costs $ 10 000. And what if a farmer does not have such an amount of money, as a company you might loose a client. With our solution such companies can offer their clients a solution for say $250 and like this keep a client." - [I2] "If we gonna to be what we wanna to be, we need to be everywhere in Tanzania. We partnered up with TechnoServe which works with farmer cooperatives and has about 28 000 farmers and Tigo which is one of the largest telecom companies. And we do not have to have guys on the ground going from village to village because that is not scalable." - [I5] "Currently we are active in India. We are looking for business partnerships there…In India we were asking ourselves how can we find a partner who could help us to understand Indian market and help us to open doors to the Indian market…?" - [I10] "We have a strategic partnership with Bayer animal health. Obviously there is huge global brand. Most people have heard of. We hope the partnership will be successful. We hope it will bring a lot of value but again be able to go to people, go to investors, go to customers or whoever and say this global company decided to partner with us." -[I11]

Table 6: Quotes made by the digital agricultural startups interviewed regarding their marketing strategies

4.3.4 Data triangulation of the marketing strategies

The first strategy presented above is user-oriented product development. For the triangulation of this strategy previous studies about joint product development were used, since direct feedback on the joint development of startup solutions with their testers could not be found on the Internet. The involvement of the customers in the development of new technologies to better understand their needs has been long promoted in the research (Lagrosen, 2005). Gruner and Homburg (2000) conducted a large-scale empirical study with managers in the machinery industry. The results showed a positive impact on new product success. The best time to involve the customers in development, according to the study, is in the early and late stages. Most of the startups interviewed did it at the early stages, when the product was extant and the users tested it to find errors and to improve usability. Another important insight from the Gruner and Homburg (2000) study is that leading users or financially attractive customers are the most suitable for the involvement in the development process. In most of the cases, the startups interviewed involved friends or acquaintances in the early stage of the solution development process. In the literature overview about the aspects of consumer co-creation during product development, Hoyer *et al.* (2010) found out that the involvement of the customers increases product effectiveness, which in turn increases the commercial attractiveness of new products.

To triangulate the importance of the various informational channels that startups use to spur growth, such as mass media, events and cooperation, the farmers' feedback about their source of information will be utilized, as well as studies in the agricultural field regarding the importance of the various informational sources. According to the interviews, there are two major communication channels: mass media and direct contact to the farmers. Some startups decided to build additional cooperation with NGOs and distributors to be able to scale the interpersonal communication.

In the interviews, some startups mentioned a positive influence on their growth rate coming from classical media sources, e.g. magazines and newspapers that are specialized in agriculture. In theory, "mass media channels are relatively more important than interpersonal channels for earlier adopters than for later adopters" (Rogers, 1983, p.201). Later, adopters become more trusting of local experience and interpersonal channels (Rogers, 1983).

On Google Play (app store), i.e. on the app page of one of the startups interviewed [I10], one of the product users left the following review on his experience with the product and his source of information:

"Useless if you don't specifically live in Germany, Scandinavia, India or Brazil. Chose

Scandinavia and it only has fruit plants/trees and herbs. Saw it on Euronews but they failed to mention these information." - Amir Banuazizi January 5, 2017

Unfortunately, it was hard to find similar mass media references for other startups. That is why for further data triangulation the latest studies (from 2012 to 2017) about the importance of different informational channels in the decision-making process for farmers were used. According to agriMa research (2013), in Germany, a weekly newspaper is the preferred source of information. 45% of the respondents see it as an important source. In the study of Yaseen *et al.* (2016), in Pakistan, more than 48% out of 160 Punjab farmers questioned ranked the media as the third most important source of information. Another study in Indian Maharashtra, with 175 participants, revealed that for 62% of the participants, newspapers were the second preferred source of information, directly behind fellow farmers (Bachhav, 2012).

According to a study in Nigeria, the mass media was the third most favorable source of information about new farming practices, following extension agents and fellow farmers (Mgbakor *et al.*, 2013). A further study of farmers in India found out that farmers normally do not use only one source of information, instead they try to be diverse (Mittal and Mehar, 2015). The study covered 1200 farming households in the most important agricultural regions in India. The results show that 28% of farmers who participated in the study replied that they prefer "face-to-face" communication during various types of meetings with various players (fairs, NGOs, State Department of Agriculture, State Agricultural University, cooperatives, middlemen, shops, dealers, etc.) and "other farmers" (farmers or relatives in the village or neighborhood) and traditional media (TV, radio, newspapers). As a source of information, 17.8% use "face-to-face" and "other farmers", and 21.6% even use four sources of information at the same time: "face-to-face", "other farmers", "traditional media", and "modern information and telecommunication technology" (Mittal and Mehar, 2015).

Apparently, "face-to-face" is also a preferable and important source of information about new technology in Australia. In the interview with the Australian "Stock Journal", a farmer who is an active user of new technologies, such as yield monitors and the solution of the [I11] startup, gives the following piece of advice: "Don't be dismissive of new technology or techniques. If you don't know how to do something maybe talk to someone or employ someone who does – or you will be left behind" (Miller, 2017).

Iowa State University, in its annual "The Iowa Farm and Rural Life Poll" in 2016, which included the responses of 1039 farmers (50% of the total farmers asked to participate), discovered that live and face-to-face communication is the most favorable method of gleaning information about most topics concerning agricultural business (Arbuckle, 2016). Among face-to-face communication methods, one-on-one consultations, workshops, training, meetings and field days were the most preferable sources.

The additional type of marketing channel that some of the startups interviewed use is cooperation. Cooperation is a process wherein different organizations come together and interact to build mutual gain or benefit (Smith *et al*., 1995). Benefits of such cooperations could include access to resources or skills, new contacts or reduced commercial risk. Cooperations help startups, among other things, to improve their chances of survival on the market and to improve their financial performance (Baum *et al.*, 2000). "By forming strategic alliances, startups can thus potentially access social, technical, and commercially competitive resources that normally require years of operating experience to acquire" (Baum *et al.*, 2000, p. 270). In the scientific literature, it is possible to distinguish different goals for cooperation: distribution, promotion, social responsibility, development of a technology or product. According to the case study about the implementation and adaptation of precision farming technologies, a collaborative approach is one of the requirements for successful innovation and diffusion (Eastwood *et al.*, 2017).

In the in-depth interviews, startups mentioned two main purposes of their cooperations: distribution and education. The main purpose of such cooperations, from the startups' perspective, is to overcome the problem of scaling the interpersonal communication and thus reduce mistrust among farmers towards new technology. In the previous chapter, several studies revealed that the farmers' lack of IT skills often keeps them from using new technology (Stricker *et al.*, 2003; Fountas *et al.*, 2005; Lima *et al.*, 2018).

In another interview with the online-blog “Samfloy”, the founder of the startup [I5] mentioned an NGO that is going to educate farmers on how to use the product of a startup; it will also explain the product’s benefits (Floy, 2017).

The startup [I10] gained, thanks to the cooperation with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), new satisfied users in India. ICRISAT organized a workshop for agricultural stakeholders in 2017 in South India. Apparently, the results of the workshop were very positive, according to some comments on Google Play. Here are some examples of the comments:

“Excellent App. Salute ICRISAT” - user Venu Gopal Pochiraju, on the June 13, 2017
“very useful app congrats to ICRISAT team” - user nainaboina suresh May 25, 2017

Some users even thought that the product was made by the cooperation partner itself:

“Very useful app developed by icrisat congratulations” - user Samrat Reddy May 25, 2017
“Congrats to ICRISAT” - ratna sekhar June 3, 2017

The cooperation with ICRISAT was mentioned in one of the interviews with one of the co-founders of startup [I10]. “In ICRISAT, we found a strong partner with an impressive expertise on crops planted in the semi arid tropics. In collaboration with ICRISAT then, a database is built up related to the main topics for these crops. In addition to the scientific support, plans are made to use [I10]’s technology within ICRISAT’s extension network that assists farmers in Telangana and Andhra Pradesh. Extension officers supported by ICRISAT can help us to adapt this technology right to the needs of local farmers” (Dias, 2016).

Two startups mentioned the cooperation only for distributional purposes. To verify the assumption, the website of startup [I2] was investigated in June 2017. Some of the distributional partners with links to the partner’s website were listed there and distributional partners in the following countries were identified: the Czech Republic, Latvia and the Ukraine. Confirmation about a cooperation between another startup interviewed, [I11], and Bayer could be found on the website of Bayer's Grow program[9], where the free trial version of the startup's solution is advertised. The "Grow solutions" website introduces Bayer partnerships in the field of new technologies. "The Bayer team and Grow partners are essential elements in giving farmers the best possible programs." Additionally, recommendations for a trial version, as well as information regarding the startups' solution and its advantages, were given.

Triangulated data supported the patterns identified from the in-depth interviews in the area of communication channels for the acquisition of new customers. Mass media was one of the most often-used channels, according to the in-depth interviews. In most of the studies, this source of information is counted among the top three. Various types of events, where the startups could directly contact farmers, also proved to be vital, since "face-to-face" contact plays an even more important role as a source of information than, in some cases, mass media.

Since interpersonal communication is one of the most effective methods, but difficult to scale, according to the in-depth interviews, some startups decided to solve this problem by starting cooperations with stakeholders mostly from the agricultural sector to educate farmers or to demonstrate the solutions at new points of distribution. This last type of channel was not used by all the startups interviewed, but it represents an interesting case, through which, according to the triangulated data, startups can even serve as a bridge to new markets – as has happened in the cases of startups [I2] and [I10].

To find out which of the strategies explored could play a decisive role in the achievement of critical mass, digital startups with critical mass will be selected, and their strategies will be compared with the ones that still have not yet achieved critical mass.

[9] https://www.growsolutions.com.au/en/about-us/partnerships/ (04.12.2018)

5 Detailed investigation of the marketing strategies that lead to the achievement of critical mass, using the example of German farm management startups

The analysis of the in-depth interviews helped gain a broad overview regarding the challenges of the digital agricultural startups and their marketing strategies. To be able to answer the question of exactly how precision farming startups can achieve critical mass, the main focus will be on German digital startups in the area of farm management that have already achieved critical mass. To obtain internal information about the marketing strategies and type of customers, a telephone interview based on a structured questionnaire was carried out.

For the purpose of this research, critical mass will be defined as a market share between 10% and 20%, according to the diffusion of innovation theory (Rogers, 1983). To calculate the market share, not only the number of customers but also the customers' turnover market share will be considered.

The German startups were selected because they sell their digital solutions on the European market, where a problem with the diffusion of precision farming technologies exists (EIP-AGRI, 2015). The strategies that German startups use could be also considered by other European digital agricultural startups and other international startups that also face the same problem on the market.

The farm management information system was chosen as a technology because, according to Gartner's Hype Cycle (Figure 11), it has already achieved "the slope of enlightenment", where critical mass for this type of technology takes place (Jarolímek *et al.,* 2017, p.70). A farm management information system (FMIS), in this paper, will be defined as "a planned system of the collecting, processing, storing and disseminating of data in the form of information needed to carry out the operations functions of the farm" (Salami and Ahmadi, 2010, p. 90). The architecture of the FMIS includes personal computers, mobile terminals, tablets, sensors, authorities, farm partners, external online services / databases and advisors (Salami and Ahmadi, 2010, p. 90). Existing FMIS are "independent software running on the user's computer with connectivity to the FMIS provider's database or a complete web-based FMIS application" (Kaloxylos *et al*., 2012, p. 132)

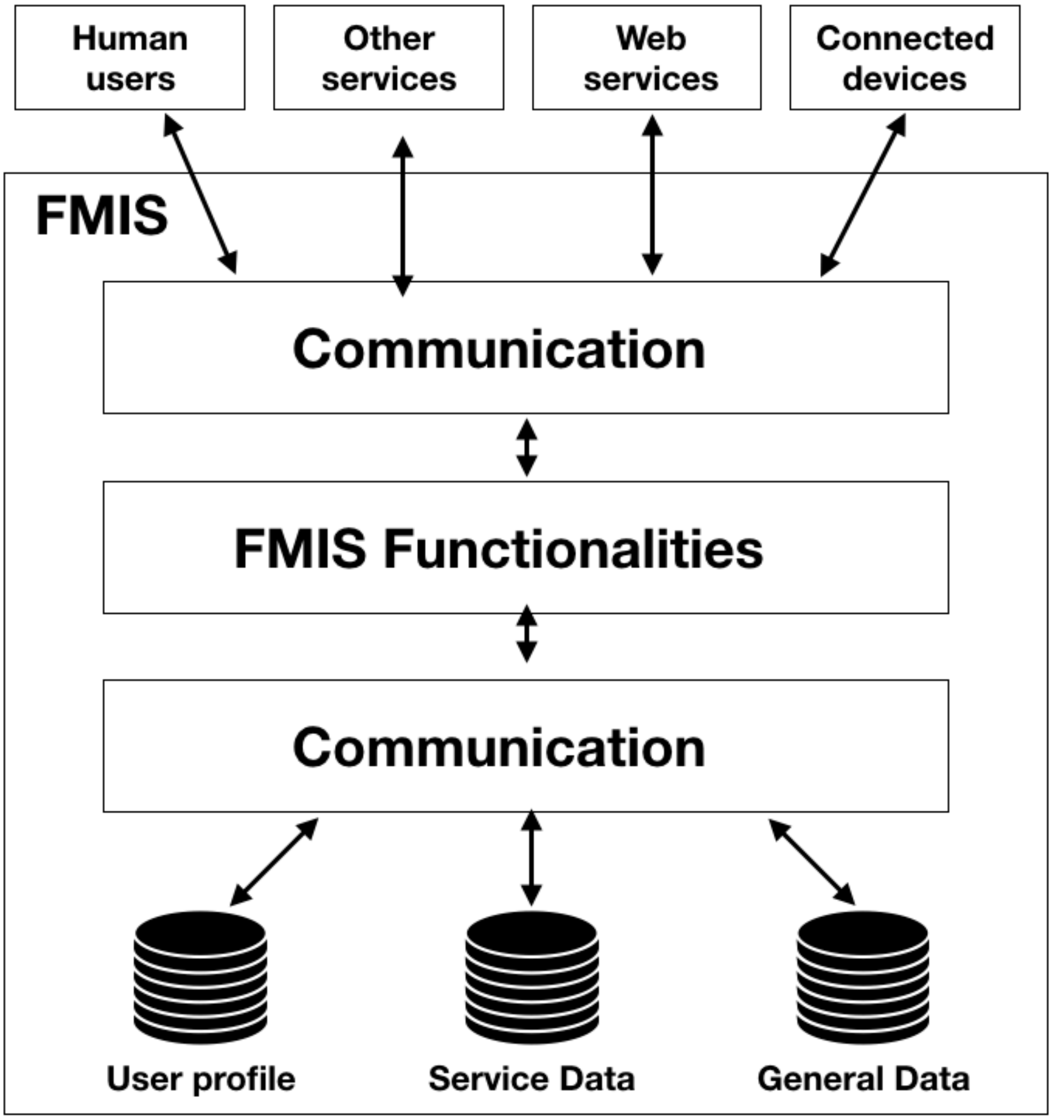


Figure 12: Structure of the FMIS (adopted from Kaloxylos *et al*., 2012, p. 132)

This type of software usually has one or several functions for certain types of operations on a farm. The fragmented functionality and incompatibility with other FMIS cause the problem of information integration, which is collected by different FMIS (Sørensen *et al.*, 2010). The issues with data integration from different types of FMIS was also identified by the EIP-AGRI (2015) as a possible barrier for the widespread use of this technology in the EU, which is going to be considered for the development of the hypothesis mentioned below

5.1 Hypotheses

In order to formulate the hypotheses for the questionnaire about marketing strategies and later for the case study, not only theories presented in the third chapter were used, but also the results of the in-depth interviews from the previous chapter and the suggestions of the 19 experts of the EIP-AGRI (2015).

5.1.1 Hypotheses concerning the technological aspects of marketing strategy

H1: Startups that have achieved critical mass provide feasible advantages for the farmers

The topic of technology usefulness was mentioned in three out of the four main theories about innovation adoption that were presented in chapter three: TAM, TID, UTAUT. Usefulness, in the theory, was defined as the perceived impact on job performance (Davis, 1989). The usefulness was selected in several previous studies about precision farming where the research objects were the farmers (Pierpaoli *et al*., 2013). In the studies reviewed by Pierpaoli *et al.* (2013), perceived usefulness and "ease of use" were the main factors that influence precision farming acceptance. The usefulness could be predicted by the advantages it offers for the farming process (Aubert *et al.*, 2012). Lencsés *et al.* (2014) investigated the importance of the advantages and disadvantages of precision farming. The results showed that the most important advantages for farmers are yield increase, income increase, reduction in the organizational work on the farm and environmental impact. Another important result of the study was the importance of understanding the advantages (direct and indirect) of the technology. This was named as one of the important factors for innovation adoption by farmers (Lencsés *et al.*, 2014; Rezaei-Moghaddam and Slaehi, 2010). To assess the first hypothesis, the founders of the startups will be asked about the advantages and the disadvantages of their technologies. Feasible advantages will be, for example, the cost reduction for pesticide use because of precision spraying or because of labor efficiency.

H2: Startups with critical mass have a free trial version

Another important component of the model is result demonstrability, although this component was mentioned only in the extended TAM model. In the Theory of the Diffusion of Innovation, the importance of the option to try an innovation before commitment was one of the important characteristics of the innovation. An opportunity to see how technology works helps in understanding its advantages. To estimate the demonstrability, the existence of a free trial version will be investigated. Free trial versions might reduce the hesitation to test new technology on the field and thus support its adoption.

To measure trialability, the startup websites and App Stores will be analyzed to find information about the trial versions. If that information is not provided online, then the founders of the startups will be asked about the test versions during the interview.

H3: Startups with critical mass have compatibility with other existing software that farmers use

Compatibility with the existing work process and software that is already being used by farmers is an important factor that can help increase the acceptance of online farm management systems, according to the experts of EIP-AGRI (2015). In his description of the innovation characteristics, Rogers (1983) defined compatibility as demonstrating consistency with the existing processes, beliefs and norms. “Consistency between existing practices and the technology features positively impact on the ‘ease of use’ perception” (Aubert *et al.*, 2012, p.512). To measure the level of compatibility, the startups will be asked if they offer an application programming interface (API). API helps, for example, to share content and data between different web applications or to integrate new functions more easily. In other words, thanks to API, users do not need to provide, for example, any additional data to a new software system because it could be gleaned from an already existing one. One of the most applied use cases for API is the login, where, if the user does not want to register, he or she can log in via Facebook.

This is possible because the website receives the necessary data like e-mail from Facebook to verify new users; users can directly start using the services of a new website.

H4: Startups with critical mass developed their product together with the farmers

Involvement of the users in the product/solution development plays an important role in commercialization (von Hippel, 1976). The experts of the EIP-AGRI (2015) emphasized that, for the spread of precision farming, the solution should be based on the real farmer's needs.

Kaulio (1998) identified three types of user involvement for product development: design for users, design with users and design by users. Each of these types of involvement has its own methods of product development. In the review of the existing joint development methods, Kaulio (1998) identified the following:

- Quality Function Deployment (QFD) is aimed at collecting customer needs to design the product and its production process (Sullivan, 1986). The user is actively involved only at the specification phase, during which the requirements for the product are formulated. Further feedback from the users during the product development process is not required.
- User-oriented product development like QFD collects the product requirements from users. However, in contrast to QFD, users also actively participate in prototype testing.
- Concept testing is a method where the users are asked to give their feedback on the ideas and low-fidelity prototypes of the products which are to be developed.
- Beta testing is a method used to receive users' feedback on the higher-fidelity prototypes to eliminate possible errors.
- Consumer-idealized design is a method to get feedback on the concept from potential users at an early stage. In contrast to concept testing, users should help develop low fidelity prototypes or help specify requirements.
- The lead-user method aims at selecting specific users who "face needs that will be general in a market place…, and are positioned to benefit significantly by obtaining a solution to those needs" (Urban and von Hippel, 1998, p.3).

The graph below visualizes each of the methods combined with the product development phase and the type of user involvement.

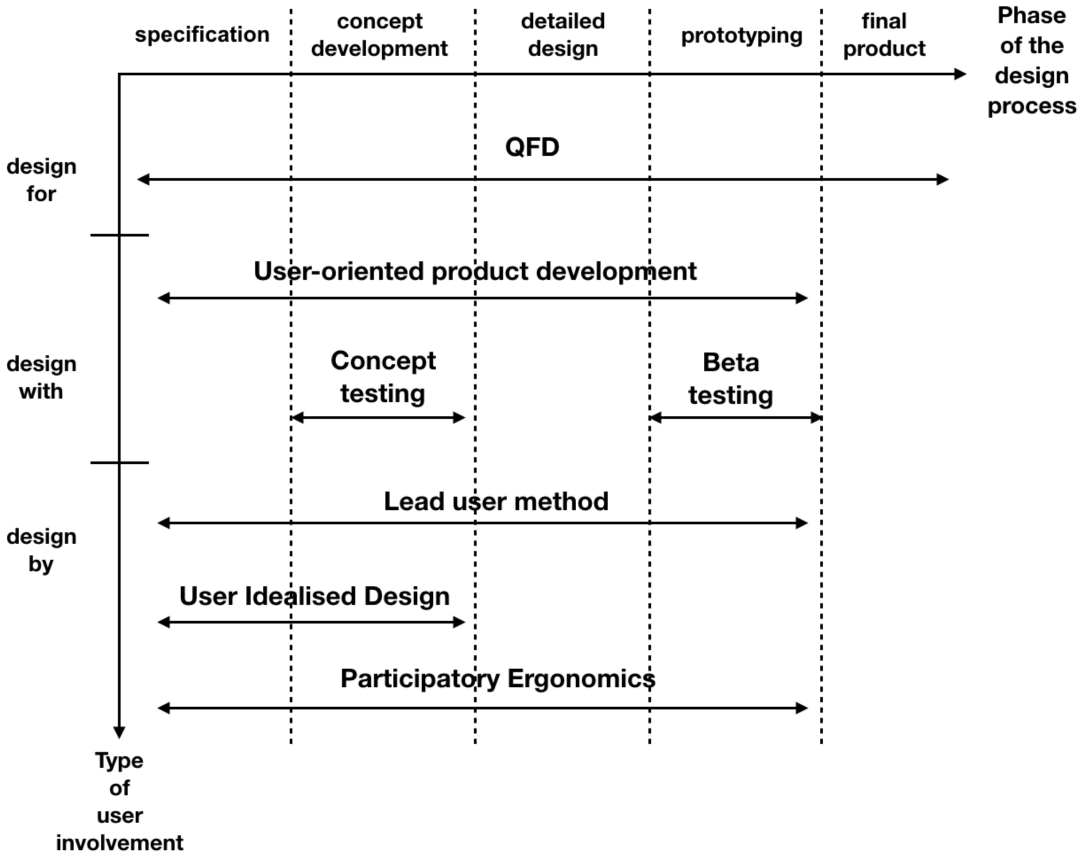


Figure 13: Methods for user involvement in product development (adopted from Kaulio, 1998, p.146)

To verify this hypothesis, the startups were asked about the methods used to develop their solution and whether the farmers were involved in achieving it.

5.1.2 Hypotheses concerning the target group and communication channels

H5: Startups with critical mass offer their product/ solution to large farms

Rogers (1983) identified a very important type of customer that is crucial to the spread of the innovation on the market: early adopters. Early adopters should work as a bridge between innovators and the mainstream market. Critical mass takes place somewhere between early adopters and the early majority. According to several studies in the EU (Fountas *et al.*, 2005; Warren, 2004; Lencsés *et al.*, 2014; Steeneveld *et al.*, 2015) and in Germany (Reichardt *et al.*, 2009; Paustian and Theuvsen, 2017), the early adopters on the market tend to be larger farms with 250 ha. or more. Large farms have not only a more substantial budget for testing new technologies, but also a greater need for them. According to statistics, the highest costs on the farm are operating costs (European Commission, 2011) and automation helps to reduce this kind of expense. To verify this hypothesis, the startups will be asked about the size of their customers' farms and the share of those customers compared with their other users. Then, the number of the large farms in the sector and their standard output will be considered, to calculate the market share of the startup. It could be that having only a few large farm companies as customers could be enough to achieve critical mass in terms of a niche market.

H6: Startups with critical mass use cooperation for educational and/or distributional purposes as an additional interpersonal channel
H6a: Startups that have achieved critical mass cooperate with various organizations for the purpose of educating farmers
H6b: Startups that have achieved critical mass cooperate with different distributors

Cooperation as one of the solutions to scale interpersonal communication was discovered during the in-depth interviews. Some startups acknowledged the problem of drawing the framers' attention to their products. The best way to persuade farmers to start using a startup's solution was contacting them directly. That kind of strategy is not scalable in the long term. Some startups came up with the solution to cooperate with the stakeholders who might also benefit from the startup's solution themselves (such as acquiring statistics about farmers' output in certain regions that otherwise would not be accessible) and/or from the target group itself (the farmers). Cooperation is one of the most researched topics in politics, sociology, psychology, anthropology and in economics. "Although cooperation has long been recognized as crucial to the success of enterprises, there is evidence that its role will become even more important in the future " (Smith *et al.,* 1995, p.9). In the technical literature, it was possible to identify a number of objectives of cooperation, e.g. distribution, promotion, social responsibility and development of technology/products (Baum *et al.*, 2000, p.270).

According to the in-depth interviews with startups, there are two main types of cooperation that should facilitate the process of critical mass achievement: educational and distributional. Education should help reduce the uncertainty level regarding innovation because farmers often do not adopt due to a lack of experience (Lencsés *et al.*, 2014). The level of knowledge about the technology also has a positive impact on the perception of its ease of use (Aubert *et al.*, 2012). Cooperation for distribution purposes was also something that some startups were employing to win over an additional customer base through third parties that have already built trusting relationships with farmers.

H7: Startups with critical mass use mass media as one of the main sources to spread information about their solution

Information plays one of the most important roles in the diffusion of innovation. According to Rogers (1983), adoption of a technology can take place primarily when there is awareness of this technology in a social system. To achieve awareness among potential users, it is necessary to communicate information about this technology. As soon as a certain level of awareness of the consequences of using the innovation has been achieved, the individual can decide either to adopt or to reject it (Rogers, 1983).

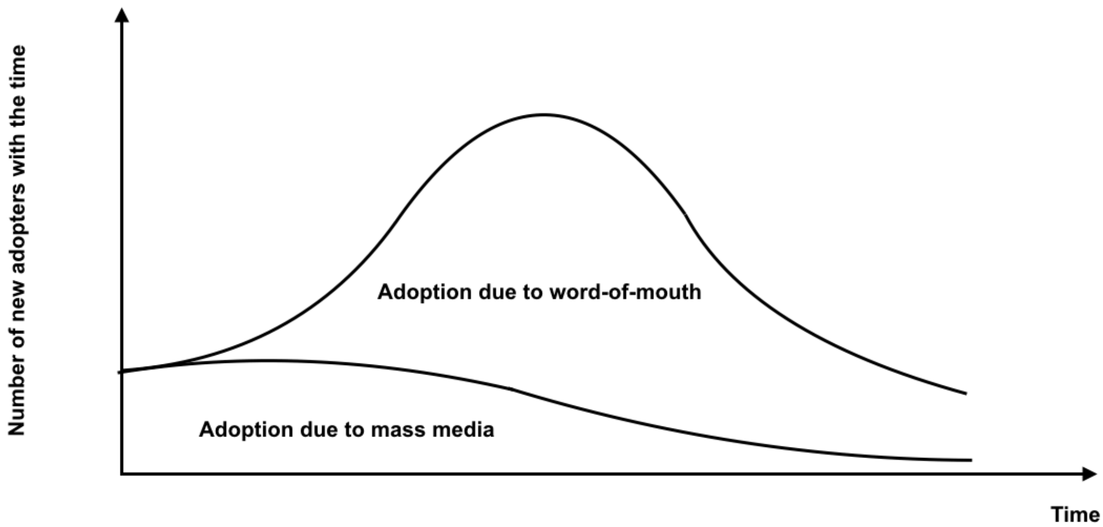


Figure 14: Adoption of the innovation curve due to the two main communication channels (adopted from Mahajan *et al.*, 1990, p.4)

The Bass model shows that there are two main sources of information: mass media and word-of-mouth (see the graph above) (Mahajan *et al.*, 1990) Innovators are the ones who adopt innovation due to the mass media and then spread the word further to imitators, who adopt due to interpersonal communication (Mahajan *et al.*, 1990). Daberkow and McBride (2003) found out that the main informational source about precision farming among farmers was mass media.

Source of the hypothesis	**Technology development**		**Communication and targeting**	
	Usefulness	**Ease of use**	**Channels**	**Target group**
Theory	H1, H2		H7	H5
In-depth interviews			H6	
Experts' recommendations		H3, H4		

Table 7: Hypotheses for the marketing strategies to achieve critical mass on the market

The formulated hypotheses presented in Table 7 above are based on the following three sources: the theory regarding technology acceptance, in-depth interviews with the startup founders and expert opinions. Experts' recommendations on the measures to stimulate the adoption of precision farming helped to create a two-pronged model for marketing strategies to achieve critical mass on the market. The first type of strategy concerns a technology and its characteristics that are key to the achievement of acceptance among farmers; the second type of strategy deals with how to approach farmers and what kind of farmers to approach so that a market share of more than 10% is gained.

5.2 Research design and data collection

To find online farm management startups, the following sources were used: f6s.com (which contains thousands of startups from all over the world), start-green.net, dlg-feldtage, FachGruppe AgTech; web search results of the keywords: "farm management startups" and "German agricultural startups"; the German informative portals "deutschestartups" and "gründerszene"; previously obtained contacts to startups during the Agritechnika fair in Hannover and GIL conference in 2016. Startups which were acquired by major corporations, such as the Berlin startup, trecker, which was bought by Yara in 2018, were excluded from the sample. Startups that were acquired normally inherit an additional customer base from a parent company and gain a new level of trust due to now being part of a well-known company. Corporate startups were also excluded because corporations use their client base to promote new products. Since corporations have already achieved critical mass, the task of on-boarding existing customers to use a new, additional product is not the same as winning completely new customers for an unknown startup that has only been on the market for a short time.

The total number of online farm management startups that matched the criteria was 10. Out of the 10 startups, 7 agreed to take part in the research. Key information about the selected startups, sorted according to the founding year, is presented in Table 8 below:

#	Founding year	Type of FMIS	City	State of FMIS	Target group of the solution
S1	2013	satellite data for soil analysis	Landshut	on the market	agricultural software developers
S2	2014	smart cow feeding	Dresden	on the market	animal farms (all sizes)
S3	2015	plant's disease analysis	Berlin	on the market	small horticulture farms and hobby gardeners
S4	2015	field monitoring and process automatisation	Bielefeld	on the market	crop farms (all sizes)
S5	2016	soil analysis	Potsdam	test phase	crops farms (all sizes)
S6	2016	online cooperation tool with the vets	Gescher	on the market	small and medium sized animal farms
S7	2016	cow monitoring	Potsdam	test phase	cow farms (all sizes)

Table 8: Farm management startups in Germany which participated in the telephone interviews

The interviews with the founders/co-founders of the startups lasted between 30 and 40 minutes. The structured questionnaire based on the hypotheses developed was sent in advance, and it contained 10 questions. Three questions had an answer option; the rest of the questions were open-ended[10]. To be able to calculate the market penetration of a startup, the questionnaire contained questions about the number and the size of the customers' farms. Considering the small number of the participating startups, the qualitative method was suited best to collect and analyze the results. This time, as the method for data collection, a telephone interview was selected.

An interview as a method generally helps capture the events in detail under natural conditions (Alshenqeeti, 2014). "A telephone interview in research terms is a strategy for obtaining data which allows interpersonal communication without a face-to-face meeting" (Carr and Worth, 2001, p.521). The telephone interview has certain advantages in comparison to face-to-face interviews, e.g. costs and time, reducing social influence on the interviewee and global access (Carr and Worth, 2001; Opdenakker, 2006).

All participants received the questions used in the interview in advance. In addition to the telephone interview, online sources were used to obtain unbiased information for testing certain hypotheses. The interview answers and the results of the online sources of information about the startups interviewed (for example, their websites, online articles etc.) were noted in the program "Numbers" (version 5.3)[11]. The answers were noted directly during the telephone conversation. The information obtained during the interview was anonymized in accordance with the wishes of the interviewees.

Since the number of the startups was too small to verify the results obtained, a data triangulation method was selected. Data triangulation helps verify obtained data by using alternative sources of information on the same topic or about the same research object (Decrop, 1999).

For the triangulation, already existing German digital agricultural companies that offer online marketplaces for farmers were selected. Online marketplaces and

---

[10] The questionnaire is presented in Annex 8.3

[11] Apple, Inc.

online farm management systems help optimize or even automate certain on-farm processes with the help of the Internet and wireless technologies. In the case of the online marketplaces, it is easier to purchase necessary machinery or plant protection and then also to sell the produce for a better price. The online farm management systems, using wireless systems, connect sensors with the software that optimizes on-farm processes such as harvesting, spraying, etc. Both online marketplaces and FMIS improve the value chain in the agricultural field and both technologies use wireless connections to fulfill their functions.

Online marketplaces could be defined as “market institutions that employ digital information technology – computers, the Internet, and the World Wide Web – to provide trading services to buyers and sellers” (Clasen and Mueller, 2006). The first online farm management software appeared approximately 15 years ago (Kaloxylos *et al.*, 2012). The first online marketplaces for farmers already appeared in the 1990s, but the real boom took place at the beginning of the 2000s (Clasen and Mueller, 2006). Several studies show that farmers faced similar challenges when using FMIS and online marketplaces: lack of trust, lack of education or training, lack of understanding of technology advantages (Reichardt *et al.*, 2009; Fecke *et al.*, 2018).

The difference between online farm management system and the online marketplace is that farm management system as a technology has a longer diffusion cycle in comparison to the online marketplace, which is viewed as a mature market element nowadays. According to the Kleffmann Group study (2016), approximately 80% of the farmers in Germany purchase online. On average, farmers purchase at least 19 times per year, as stated in the study. The favorite purchases online are machinery and spare parts, followed by workwear and office supplies. On the other hand, according to a survey of 100 farmers in Germany carried out by PriceWaterHouseCoopers in 2016, only 29% use anFMIS and 3% are testing one (Bovensiepen *et al.*, 2016). In the Bitkom report from 2016, only 12% out of 521 interview participants from agricultural enterprises use online farm management platforms (Rohleder and Krüsken, 2016).

To find companies that would be suitable for data triangulation, a list of companies that were presented in Clasen's dissertation (2005) was used. This list was enhanced by the newer companies (founded after 2003) that were discovered during a web search[12] conducted using the following German keywords: "Marktplatz", "Landwirte", "Online", "Kaufen", "Landmaschine", "Schutzmittel". In total, 18 online marketplaces in Germany were found. In Table 9 below, the overview of the selected marketplaces sorted according to the founding year is presented.

#	Founding year	Type of goods that are traded on the marketplace	State of the marketplace	Target group
1	1998	agricultural machinery	on the market	large farms
2	1999	online connection between retailer and farmer for purchasing various goods	on the market	medium-sized farms
3	2001	agricultural machinery	on the market	all types of farms
4	2001	jobs in the agricultural sector	on the market	all types of farms
5	2001	land and property trading platform	on the market	all types of farms
6	2004	agricultural machinery	on the market	all types of farms
7	2016	plant protection	on the market	all types of farms
8	2017	advertising for agricultural goods	on the market	small and medium-sized farms
9	2017	online connection between retailer and farmer for purchasing various goods	test phase	medium-sized farms

Table 9: Online marketplaces which participated in the telephone interviews

Some of the marketplaces, like landimmo, tec24, and landjobs were part of one large corporation, i.e. Raiffeisen. To obtain data about online agricultural marketplaces, a telephone interview was used as the method. Six companies that represent nine online marketplaces participated in the interview. The results of the telephone interviews will be presented in a descriptive form.

[12] Google web search

5.3 Marketing strategies of FMIS startups with critical mass

To calculate the market share of each startup interviewed, the statistical data about the number of agricultural enterprises and their standard output[13] (SO) was analyzed. The statistical data for 2016 was obtained on the German Federal Ministry of Food and Agriculture website (DESTATIS, 2017) and is presented below in Table 10.

The startups that participated in the telephone interview offer their solutions to different groups of farmers: from crop to animal farms. One of the startups interviewed, for example, offers its services also to hobby gardeners as well as small horticultural farmers. Statistics on the number of hobby gardens is provided by the federal organization for hobby gardeners ("Bundesverband Deutscher Gartenfreunde e.V.") in Germany.

Table 10 below shows the main types of customers for which the startups interviewed offer their solutions: crop, animal, horticulture farmers and hobby gardeners. Additionally, for the purpose of the verification hypothesis H5 (which says that startups targeting large farms can achieve critical mass more quickly) the target group was divided into two groups: 1) small and medium farms and 2) large farms.

[13] Starting from 1999, there were several changes in the collection of agricultural data. The latest important change was in 2010. Since 2010/2011, farms smaller than 5 ha are not included in the statical data, except when those farms have a certain number of animals or grow certain types of plants. A further important change in the collection of the statistical data is that the EU introduced new classifications for the size of agricultural enterprises based on farm turnover, which is measured as standard output (SO). The classification of farms is now based on the type and amount of income. According to this classification, farming activity could be either a primary or an additional source of income. All farms that have SO < 50,000 EUR/per year and less than one employee are considered small companies or an additional income. In all other cases, farming activities count as the main source of income and as medium or large companies. Since there is no additional fixed definition that separates medium and large companies according to the Eurostat, for the purpose of this research, the large companies will count as those with SO ≥ 1,000,000 EUR, and the medium-sized companies between 50,000 and 1,000,000 EUR.

Type of farm	Total number of farms	Approx. SO (in Mill. EUR)	Number of small and medium farms	Approx. SO small and medium farms (in Mill. EUR)	Large farms	Approx. SO large farms (Mill. EUR)
Crop farms	83,939	10,382	82,347	7,274	1,592	3,108
Animal farms	161,885	33,989	157,780	25,000	4,105	8,989
Cow farms (including dairy)	145,892	25,375	143,479	19,807	2,413	5,568
Pig and poultry farms	15,993	8,614	14,301	5,373	1,692	3,241
Horticulture farms	6,359	3,088	5,642	1,513	717	1,575
Hobby gardeners	910,000	-	-	-	-	-

Table 10: Market estimation for the target groups of the FMIS startups

In order to measure market share, two indicators were used: market share in terms of the total number of farms and in terms of the SO. That is why the table above displays both the total number of farms for each type of customer as well as the SO. These two indicators were also calculated for the size of the farms. The market share in the hobby gardener segment could be measured only in total numbers, since this sector does not have to provide any statistics about the SO or size of a garden. The SO for each segment was calculated as an interval average, so it appears as an approximate number in the table.

Critical mass in the research presented here was defined according to Rogers (1983) as a market share that lies between 10 and 20% of the market. To be able to calculate the market share, the startups were asked to provide a number of customers and also the number of small, medium and/or large-sized farms they have as customers. Based on this information and the statistical data presented above in Table 10 a market share for each startup interviewed was calculated.

Table 11 below presents the results of the market share calculations.

Startup number from Table 8	Approx. market share (%) in terms of the number of customers for the whole segment	Approx. market share(%) in terms of the large farms	Market share (%) in terms of the SO
S1*	-	-	-
S2	1.2	24	7
S3**	11	-	-
S4	2	63	21
S5***	-	-	-
S6	0.2	-	0.1
S7****	-	0.02	0.04

* S1 does not sell its software directly to the farmers; instead it sells the software as an integration to already existing small and medium-sized software companies that sell their own software to the farmers. But S1 plans to market their solution directly to the farmers in the future. There is only one software company on the German market that is an S1 customer.
** S3 has only hobby gardeners and small gardeners as its target group.
*** S5 was in the pilot phase and the technology was accessible only to a closed group of test customers.
**** S7 is also in the test phase and works with a few large farms to improve their products.

Table 11: Market share of FMIS startups which participated in the telephone interview

The startups selected for the interview were in various stages of development: some were openly selling their solutions on the market (S2, S3, S4, S6) others were in the test-phase where they had a specific test-group and could not really share the actual number of customers (S5, S7). One startup (S1) even decided not to sell their solution to the farmers directly, but to cooperate with other IT companies that already have substantial customer bases and develop applications for the farm management systems jointly. That is why the table above (Table 11) does not show a market share for each of the startups interviewed. In addition to the market share in terms of the total number of farms in the sector and SO, a niche market represented by the large farms was included, since this segment of the market represents early adopters.

According to the data presented above (Table 11), only two startups achieved critical mass: startups S3 (in terms of the total number of the customers) and S4 (in terms of the SO in the targeted segment). Startup S3 might have an even higher market penetration rate than displayed in the table above due to its API. The API of this startup is used by one of the large German corporations that produces plant protection products and holds more than 30% of the market.

One startup (S2) has not achieved critical mass in the whole segment it targets, but only in the niche market (by targeting large farms) where it has a penetration rate of approximately 24%. If this startup should soon win over several large farms, then it can easily gain the missing 3% to reach critical mass in terms of SO on the whole market.

In Table 12 below an overview of the strategies that startups use to market their solutions is presented.

Number of the hypothesis	**Hypothesis**	**Number of the startups from Table 8 with critical mass**			**Number of the startups from Table 8 that did not reach critical mass**			
		On the niche market	On the whole market segment				In the test phase	
		S2	S3	S4	S1	S6	S5	S7
H1	Feasible advantages	x	x	x		x	x	x
H2	Trial Version	x	x	x	x	x	x	x
H3	API	x	x	x	x	x	n/a	x
H4	Joint development with farmers	x	x	x	x	x	x	x
H5	Large farms as niche market	x		x			n/a	x
H6a	Cooperation for educational purposes	x	x				n/a	
H6b	Cooperation for distribution purposes	x	x			x	n/a	
H7	Mass media	x	x	x		x	n/a	x

Table 12: Marketing strategies of the FMIS startups which participated in the telephone interview

The startup identification numbers (S1 to S7) in Table 12 correspond to the numbers of the startups in Table 8. In order to better compare the strategies of the startups, the startups still in the test phase were identified separately.

The comparison shows that there are only slight differences in the strategies between the startups with and without critical mass. The most common strategies for the startups were providing feasible advantages, offering a trial version and API, as well as joint product development.

Startup S3 with critical mass combined two strategies on the German market. One of the strategies was direct marketing to the customers via mass media; the second strategy was the use of integration (API) as an additional marketing channel and business model. Through mass media, the startup could win approximately 11% of the market. Additional users are gained via the chemical companies that use the startup's API to help their customers to properly identify a plant disease and receive better advice on plant protection to cure it or to save the rest of the healthy plants.

Two other startups (S2, S4) that have achieved critical mass have a high penetration rate within the niche market represented by large farms and a relative low share in the segment of the small and medium enterprises. Both startups have almost equal numbers of small and medium-sized farms as well as large farms as customers. However, precisely due to providing solutions to the large farms, these companies could potentially achieve critical mass.

There were, however, two differences in the marketing strategies between the startups with critical mass: 1) cooperation for educational and distributional purposes and 2) concentration on large companies. Startup S2, which has not yet achieved critical mass in the whole segment of the market, followed all the strategies that were used for the hypotheses. But perhaps the combination of the target group and certain types of strategy play a more important role. The idea of different strategies for different types of customer groups makes sense in times of individualized market-targeting and could also be important in the agricultural field considering different needs and expectations of different farm types. As one of the co-founders of a farm management startup said in the in-depth interview: "You ask 50 people what they want to see next and you get 48 different answers".

Startup S6 follows almost all the strategies that the S3 startup with critical mass does; the only exception is the cooperation for educational purposes, which could be decisive, considering the suggestion of the EIP-AGRI (2015) that small and medium-sized companies have not yet realized the benefits of the new farm management systems. However, it is important to mention that startup S6 was founded one year later, making a direct comparison difficult.

To verify the strategic patterns identified from the telephone interviews with FMIS startups, a data triangulation with online marketplaces will be made.

5.4 Data triangulation: German online marketplaces and FMIS startups

In the telephone interview with marketplaces, three startups that started their activities in 2016 and 2017 took part: one large corporation that owns several online marketplaces and four medium-sized companies. One of the marketplaces is part of an agricultural publishing house. All companies wished to remain anonymous. To find out if a company had achieved critical mass, the interview partners were asked about their market share. The startups were also asked about their number of customers.

Among the new marketplaces, there was no company that has achieved critical mass on the market. One out of the three startups interviewed is in a test phase. The marketplaces that have achieved critical mass have been on the market between 15 and 20 years. One company owns three marketplaces (marketplaces numbered 4, 5 and 6 in Table 9). In the interview, the representative of the company called special attention to the newest marketplace that was founded in 2004 and sells machinery and machinery parts. That is why, in the table below (Table 13), the marketing and technology strategies of this particular „new“ marketplace were presented. One company, despite its long existence on the market, has still not achieved a 10% share of the market. The results of the telephone interview are presented in Table 13 below. The number of marketplaces has been taken from Table 9.

Number of the hypothesis	Strategies	Number of the companies from Table 9 with critical mass			Number of the companies from Table 9 that did not reach critical mass			
								in test phase
		1	6	3	2	7	8	9
H1	Feasible advantages	x	x	x	x	x	x	x
H2	Trial version	x	x	x	x	x	x	x
H3	API	x	x	x				x
H4	Joint development with farmers	x	x	x				x
H5	Large farms as niche market	x	x					
H6a	Cooperation educational purposes							
H6b	Cooperation for distribution purposes	x	x	x				
H7	Mass media	x	x	x	x	x	x	x

Table 13: Marketing strategies of the online marketplaces which participated in the telephone interviews

The estimation method used to discern the market share for the marketplaces was similar to the estimation of the market share for the FMIS startups. The exceptions were certain older marketplaces where not only the approximate number of users was requested, but their own estimation of the market share as well. For those marketplaces that achieved critical mass, it is possible to separate two main strategies for market penetration: 1) through corporate partners; 2) cold calling. Cold calling[14] is a new type of strategy that was revealed in the interviews about the most effective channels for customer acquisition, but it was not included in the data triangulation.

Two out of three marketplaces with critical mass were founded by corporations that at the time had already been on the German agricultural market for a while. To win over first customers, the corporations used the existing channels to reach farmers. Thus, in the shortest time, they could gain more than 10% of the market

[14] According to the Cambridge Dictionary “cold-calling is the activity of calling or visiting a possible customer to try to sell them something without being asked by the customer to do so”.

in Germany. Today, the main marketing channel for those online marketplaces are newsletters or social media and, in some cases, cold telephone acquisition. It is also interesting that all the online marketplaces with critical mass have an API that allows the customers to import the information from other existing platforms that they use.

The marketplaces that have not achieved critical mass offer no API; only one startup is currently developing one. Each of the companies with critical mass developed partnerships with the stakeholders, e.g. small distributors or export distributors. Only one company that still has not achieved critical mass has partnerships that were arranged by the investors of the company. The companies with critical mass also actively invite their users to jointly develop and test new features of the marketplaces. Only one marketplace that has not yet achieved critical mass also does the same. The main customers of the marketplaces with critical mass are different: one marketplace has targeted mainly small and medium-sized farms, the second has a mixture of a small and medium-sized as well as large farms as clients, and the third marketplace works only with large farm holdings. All the marketplaces that have not yet achieved critical mass have small and medium-sized farms as customers.

The patterns of the online marketplaces' strategies reveal major differences between the companies with and without critical mass. Cold calling, not included in the table above, and use of mass media are the most-used channels among online marketplaces. In the telephone interview with the FMIS, some startups also mentioned cold calling as one of the methods to reach new customers. After the marketing strategies of the online marketplaces were compared, the next step was to compare those strategies with those of the FMIS startups. Cold calling will be not used for the comparison, since this type of strategy is not common to FMIS startups with critical mass.

According to the results presented below in Table 14, all the companies with critical mass followed similar strategies except targeting large farms and cooperation for educational purposes, which seems to be more common to the FMIS startups.

Number of the hypothesis	Marketing strategy	Number of the online marketplaces from Table 9 with critical mass			Number of the FMIS startups from Table 8 with critical mass		
		1	6	3	S2	S3	S4
H1	Feasible advantages	x	x	x	x	x	x
H2	Trial version	x	x	x	x	x	x
H3	API	x	x	x	x	x	x
H4	Joint development with farmers	x	x	x	x	x	x
H5	Large farms as niche market	x			x		x
H6a	Cooperation for educational purposes				x	x	
H6b	Cooperation for distribution purposes	x	x	x	x	x	
H7	Mass media	x	x	x	x	x	x

Table 14: Marketing strategy comparison of online marketplaces and FMIS startups with critical mass

Cooperation for distribution purposes appears to be an important strategy, as 5 out of 6 companies with critical mass followed it. All the companies with critical mass took the technical aspects of the technology seriously and offered feasible advantages, trial versions, the possibility of the integration of their functions into other products or data sharing as well as joint testing of their solution with farmers. The use of mass media as a relevant communication channel is also something common to all the companies.

The qualitative investigation into the strategies of the marketplaces and FMIS startups with critical mass showed some differences in the strategy types. Cold calling as an interpersonal channel for online marketplaces with critical mass is an important source for growth, while FMIS startups focus more on online marketing or use educational cooperations. Two out of three startups with critical mass have educational cooperations.

Although the results presented do not provide an exact recipe for a successful marketing strategy for critical mass achievement, it is possible to recommend that all startups consider technical aspects of the technology, especially the API. Companies without critical mass often do not have integrations for data sharing. Mass media as well as cooperation for distribution represent an important communication channel and are also not always used by the companies without critical mass. Concentration on large companies in the beginning can help gain a significant market share in terms of the standard output; it could be a good basis for expansion to further segments of the market.

To find out more about how the strategies presented above work and what impact they have on reaching critical mass, an extremely successful German startup, PEAT, was studied. As the investigative method, a case study was selected, as PEAT is currently a unique example of an FMIS startup on the agriculture market that could gain impressive growth in several countries at once.

5.5 Case study on how the German startup PEAT has achieved critical mass

5.5.1 Case study as a qualitative method

Case study is one of the most-used qualitative methods, but it was not immediately accepted in the social sciences (Yin, 2002). The reason behind the difficulty in using the case study was the lack of structure, because there were no specified scientific guidelines for defining an object of the case study, data collection methods and appropriate methods for analysis (Yin, 1984). The most often used argument about qualitative research and especially the case study is that it is subjective. However, subjective perception is at the same time an objective reality, because the fact that “human subjects create, communicate, and hold are part and parcel of the real world that a social scientist receives as the subject matter under investigation” (Lee and Baskerville, 2003, p. 230). The case study is not only a suitable method to explore the subject; it is also can be used to explain certain phenomena (Yin, 1984).

A case study represents an investigation of a complex social phenomenon that aims to answer “why” or “how” questions and preserves important characteristics of real-life events (Yin, 1984). An object of the case study can be an individual or a group, organization, situations, events, programs, activities (Yin, 1984; Hancock and Algozzine, 2006). For the present case study, the question and the subject are as follows: How has the German startup PEAT achieved this extraordinary growth by using the same strategies as some other startups mentioned in the research presented here.

There are several types of case studies: exploratory, descriptive and explanatory (Yin, 1984); ethnographical, historical, psychological or sociological (Merriam, 2001); intrinsic, instrumental and collective (Stake, 1995). Exploratory studies aim at developing certain hypotheses and propositions for further research and often contain a “what” question (Yin, 1984). In contrast, an explanatory case study looks for answers to certain propositions. A descriptive case study seeks to provide a thorough description of a certain phenomenon. Ethnographic case studies seek to discover “patterns of behavior, customs, and ways of life of a culture-sharing group” (Hancock and Algozzine, 2006, p.31). In a historical case study, previous events are analyzed, in which the event’s participants are interviewed, documents are investigated to uncover factors that caused the event and its results (Hancock and Algozzine, 2006). In a psychological case study, human behavior is the main research subject; in a sociological case study, the research subjects are social phenomena like religion, urbanization, politics etc. Intrinsic case studies aim to investigate particular phenomena that generally do not necessarily contribute to a generalization or development of a theory. Instrumental case studies, in contrast, seek to form a better understanding of a theoretical question or problem (Hancock and Algozzine, 2006). Contribution to the theory is one of the main aims of the collective case study, where several instrumental case studies serve as the basis for developing theories about similar case studies. The present case study could be described as an instrumental, descriptive case study.

As data for the case study, quotes of key participants, interviews, articles, videos, etc. could be used. What is important during data gathering is a diversity of the sources to avoid biases and for a better understanding of the complexity of a subject (Yazan, 2015). An important strategy to verify the results of the case study and minimizing incoherencies is by sharing it with “those examined in the study” (Hancock and Algozzine, 2006). This will be done in the present case study. According to Yin, a case study design should include the following components: “a study’s questions; its propositions, if any; its unit(s) of analysis; the logic linking the data to the propositions; and the criteria for interpreting the findings” (Yazan, 2015, p.140). Propositions or hypotheses represent the conceptual foundation of the study and are based on the literature reviewed (Hancock and Algozzine, 2006).

The model presented below, composed of seven hypotheses, will be used as a conceptual framework for the present case study. For the data interpretation, different strategies will be selected, as the case study may include quantitative as well as qualitative methods for data analysis (Yin, 1984).

Hypothesis	**Data**	**Analysis method**	**Results**
H1: Feasible advantages	Description of the advantages of the service on the website; feedback of users on the Google Play website collected up to 17 August 2018	Topic-modelling of the feedback	Main topics of the feedback triangulated with the service description of the startup and its advantages
H2: Trial version	Information on the website and Google Play about the costs of the app use	Qualitative	Information about the costs of the startups’ service
H3: API	Information on the website, websites with the libraries containing information about the API, in-depth interview	Qualitative	Existence of the API and its use
H4:Joint development with the farmers	Information from the in-depth interview with the co-founder	Qualitative	Detailed information about the app development
H5: Large farms	Interview with the co-founder, online articles	Qualitative	Information about the target-group
H6a: Cooperation for educational purposes	Online articles, in-depth interview with the co-founder	Qualitative and topic-modelling of the articles’ content	Description of the types of projects created for educational purpose
H6b: Cooperation for the distribution purposes	Online articles, in-depth interview with the co-founder	Qualitative and topic-modelling of the articles’ content	Description of the types of projects for distribution purposes

Hypothesis	Data	Analysis method	Results
H7: Mass media	Online articles about PEAT and their app Plantix	Topic-modelling of the articles	Description of the type of the articles and their content

Table 15: Methodological design of this case study

5.5.2 Topic-modeling as a method for quantifying qualitative data

While working with the qualitative data, it is sometimes difficult to achieve an unbiased analysis due to the potential subjectivity of the researcher. To minimize such bias during the analysis of the Plantix app reviews and articles about PEAT and Plantix, one of the text-mining methods, topic-modeling, was used. “Topic modeling algorithms are statistical methods that analyze the words of the original texts to discover the themes that run through them, how those themes are connected to each other, and how they change over time” (Blei, 2012, p.77). This method helps to analyze how “words contained in a consumer review reflect a latent set of ideas or sentiments, each of which is expressed with its own vocabulary” (Büschken and Allenby, 2016, p.2). Consumer reviews provide information about their perception of the technical aspects, ease-of-use, usefulness, problems and other aspects of a solution. One of the basic models for topic modeling is Latent Dirichlet Allocation (LDA). This model assumes that there is a fixed number of topics in the documents being analyzed or, in this case, reviews or articles. Each review has a certain number of topics (θ_d), and each topic has a discrete probability distribution of words that characterize it (Büschken and Allenby, 2016). Words that have a high probability of appearing in connection with the topic are then attached to that topic. For the purpose of this research, the LDAvis model was used. “LDAvis is a web-based interactive visualization of topics estimated using Latent Dirichlet Allocation that is built using a combination of R and D3” (Sievert and Shirley, 2014 p.63). This model helps visualize the meaning of each topic, the relationships between the various topics and the importance of each topic. In the research presented here the data was analyzed with R Version 3.5.1 GUI 1.70 El Capitan build (7543) in the R Studio Version 1.1.453.

The LDAvis package visualizes the prevalence of the topic in the reviews through the size of the circles. The size of the circle shows the proportion of the words that characterize the topic in the whole document. The higher the portion of the terms in the document is, the bigger the circle is. One of the advantages of LDAvis in comparison to the LDA is the possibility to filter terms that have high frequency only in a certain topic. In LDA, often words that are most frequent in all the documents and not necessarily specific to that topic appear at the top of the terms list (Sievert and Shirley, 2014). This adjustment is important, since topic interpretation is not easy (Chang *et. al.*, 2009).

To calculate the rank *(r)* of the word in the topic *k*, Sievert and Shirley (2014) developed the following model: where φ_{kw} is a probability of the term $w \in \{1,\ldots, V\}$ for the number of topics $k \in \{1, \ldots, K\}$, where V is the number of terms and p_w is the marginal probability of term *w* in the corpus. The corpus contains all the documents, or in this case, all reviews or all articles. To determine the relevance of the term *w* in the topic *k,* the parameter λ *was* introduced, where $0 \leq \lambda \leq 1$ as:

$$r(w,k|\lambda) = \lambda \log(\varphi_{kw}) + (1-\lambda) \log(\varphi_{kw} / p_w),$$

λ provides the weight for the term w in the topic k. Thus, when λ = 0, the word has its own lift; when λ = 1, then it is ranked according to its probability. To define an optimal weight for λ, the authors did a case study that revealed that the optimum value to find topic-relevant terms is when λ = 0.6. For the purpose of this research, λ = 0.6 was set as the optimum value as well (Sievert and Shirley, 2014).

In the present case study while using the model described above the number of iterations was set to 5000 to train the model, because LDA is an iterative algorithm, "One iteration equals one round of sampling the training data and in one synchronization pass all the model data are synchronized" (Zhang *et al.*, 2015, p. 1). The more iterations are done, the more stable the model is. The optimal number of topics for a small corpus could be selected based on the outcomes; for a larger set of data, it is recommended to use a matrix factorization method (Arun *et al.*, 2010). Big data in this context means "a phenomenon defined by the rapid acceleration in the expanding volume of high velocity, complex, and diverse types of data” (TechAmerica Foundation’s Federal Big Data Commission). Since the set of data that is used for the current case study cannot be described as complex or expanding at high velocity, the optimal number of topics will be selected based on the visualized results and iterations. To prepare the data for analysis, the following steps were taken: 1) all the special signs like “)”, “(” were removed from the reviews; 2) all the letters were made lower-case; 3) all the numbers in the review were removed; 4) all the stop words[15] and all terms that appear less than 5 times in the reviews were removed. Additionally the positive and negative reviews were sorted in accordance with the reviewers’ rating (1 to 5 stars). A positive review was defined as a review that received 4 or 5 stars. Negative reviews were defined as reviews that received 1 or 2 stars.

5.5.3 Results of the case study on the German startup PEAT

PEAT is a startup company that, according to their website, provides “automatic image recognition for plant damage”. Currently, the startup has two solutions on the market based on an image recognition algorithm developed for plant diseases: the Plantix app and surveillance systems for indoor faming and greenhouses. The present investigation was done for the marketing strategies of the Plantix app as one of the first solutions brought to the market by the startup.

The app works as follows: the users of the app can take a picture of a sick plant and, through image recognition, the diagnosis will be determined and a possible cure method will be suggested to the user. The farmer can also receive additional advice from the expert community who also use the app.

The PEAT startup was founded in 2015 in Hannover by six co-founders: Simone Strey (CEO, who is a geographer specialized in geobotany and soil science), Pierre Munzel (responsible for PR), Alexander Kennephol (an expert in plant diseases and one of the developers of the plant diseases database), Robert Strey

[15] A stop word represents commonly used words such as “the”, “a”, “an”, “in” etc. that are removed during the preparation of the text for the analysis. A special package from R which is called tidytext (package) Stop_words was used to remove stop words. The package includes English stop words from three different lexicons/dictionaries as a data frame. The snowball and SMART sets are pulled from the tm package. Words with non-ASCII characters have been removed. The source of the stop word was “SMART".

(an expert in machine learning), Bianca Summer (the coordinator of local cooperations in African countries) and Korbinian Hartberger (responsible for communication)[16]. PEAT started as a project at the Leibniz University, where the founders received the German grant “EXIST”. The grant provides funding for one year for research and solution development that must later be commercialized. According to the in-depth interview with one of the co-founders, before the startup was founded, the founders were already good friends. Three startup co-founders (Simone, Pierre and Robert) had already previously gathered experience as founders of the NGO “Green Desert e.V”, which no longer exists. The NGO coordinated several agricultural projects in Ghana and Senegal. According to the in-depth interview with one of the co-founders Pierre Munzel, during this time, they discovered that African farmers sometimes use toxic and inappropriate means to cure the plants.

“There we had experienced the Eureka moment when we got to know local farmers who have learnt a very special way to keep the ants away from the lettuce. For this they used battery acid. So they just broke the normal battery and dripped the inside of the battery directly on the lettuce. That was the moment when we realized that those farmers need an elucidation”.- in-depth interview with the co-founder

This experience served as an inspiration for the initial idea of the Plantix app. For the development of the first version of the app, according to the in-depth interview, a group of approximately 100 friends and acquaintances was created. The first target group using the app were the hobby gardeners. That is why the first version of the app released in 2015 was called “GartenBank”. In one interview with the blogger of “Kistengrün“,(a „green“ blog) the co-founder Simone Strey said that the initial version of the app could recognize over 90 plant diseases (Mel, 2015). The database of the images and diseases started as a crowdsourcing-science project where everyone had an opportunity to send an image of a sick plant and even mark the diseased area. Thus, through the “GartenBank” app, more than 6000 images were collected (Mel, 2015). Those images were used to train the machine-learning algorithm for plant and disease recognition.

[16] Information provided on the web-site about the founding team

In 2016, the app Plantix was released. The target group of this app was not only hobby gardeners but small horticultural farmers. After Germany, the next country where the app was launched was India, according to the in-depth interview with the co-founder Pierre Munzel. Three years later, the Plantix app built a presence in Germany, Nepal, India and Tunisia. On Google Play, there were more than one million downloads, over sixteen thousand ratings[17] and more than 3,000 reviews

5.5.3.1 User's perception of the Plantix app's feasible advantages

To test the first hypothesis about the advantages of the solution, 3,424 reviews in English and 129 reviews in German from the Google Play Store will be used that were submitted before 17 August 2018. The main advantages of the app will be described according to the information on the startup press kit. Then, the topics of the overall review will be presented, as well as the top 30 terms that characterize it. Then, the positive and negative reviews will be separately analyzed to see what the users like the most about the solution, what is still missing and if the value that a startup wants to deliver is correspondingly appreciated and understood by the target group.

According to the press kit about the Plantix app, its aim is to provide: 1) diagnosis for a sick plant; 2) advice on its treatment with special focus on biological control mechanisms. This aims to help farmers improve the harvest, because according to the press kit, approximately 30% of the world-wide harvest is damaged by various plant diseases.

5.5.3.1.1 User's perception based on the reviews in English

After cleaning the reviews in English, there were 3,421 valid reviews out of 3,424. 2,851 reviews were positive and 372 were negative. 198 reviews had 3-star ratings and are as well presented in the table below in "all reviews".

[17] The app has only been developed for use with Android devices so far.

There is a large discrepancy in the length of the reviews. The minimal length has only two characters while the longest has 955. The negative reviews were on average longer than the positive ones. However, the longest review was a positive one.

The table below presents a comparison of the positive and negative reviews and their length.

Parameter	All reviews	Positive reviews	Negative reviews
Min. review length	2	2	2
Max. review length	955	955	386
Average review length	29	25	34
Median review length	13	13	51

Table 16: Statistical parameters of the review length (in characters) in English

To select the optimal number of topics that could best describe the reviews, a varied number of topics was tested within the model: 30, 20, 10 and 5. The model with 5 topics showed plausible results concerning content of the reviews.

The most frequent topic according to the graph below is **number 1**; the four further topics seem to have similar size. The size of the topic corresponds to the prevalence in the overall reviews. The bigger the topic is, the more frequently it appears in the reviews. There is also one cluster of three topics that have similarly frequent terms characterizing them. The axis in the model does not have certain definitions but helps to visualize the difference/relationship between the topics though the distance between them. An example of the topic visualization with the LDAvis is presented below in Figure 15.

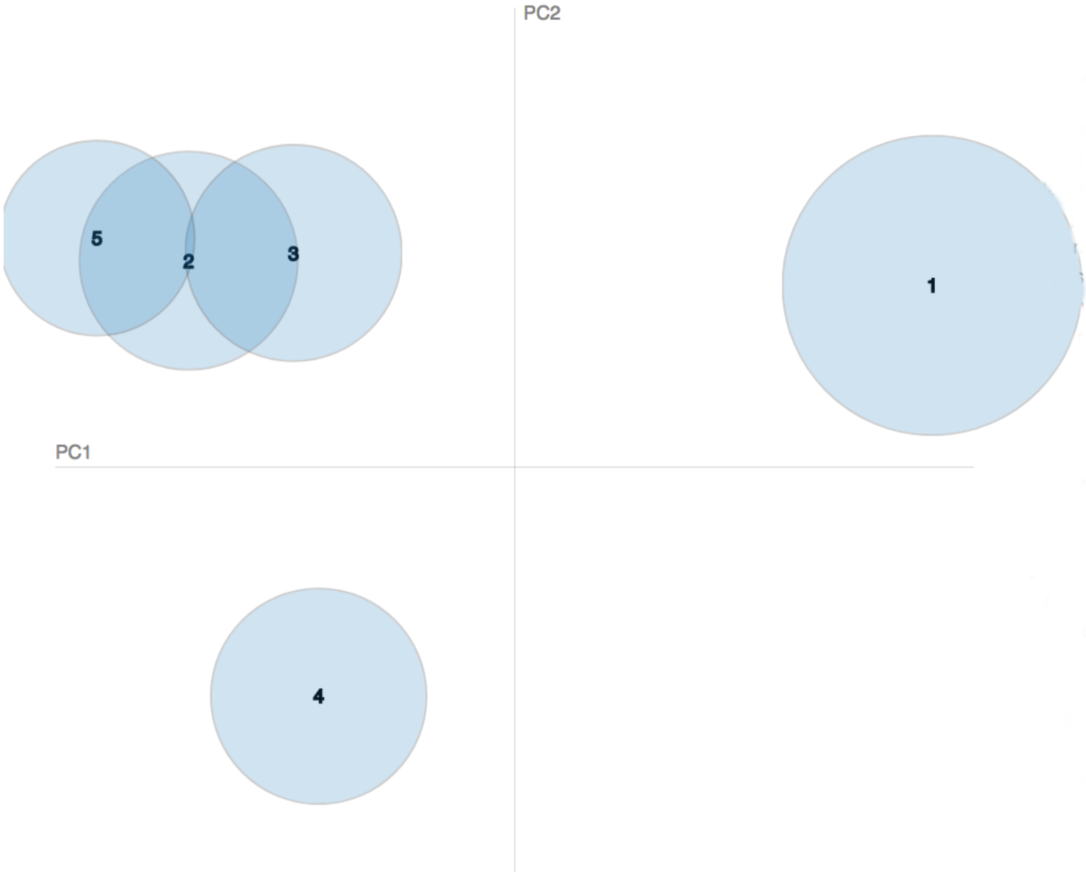


Figure 15: Size of the topics for the reviews about the Plantix app in English visualized with LDAvis

Topic number 1 concentrates on the identification of the plant's diseases function of the app and its quality. It is characterized by such terms as "app, plant, good, disease, crop, identify, problem, recognize, photo" etc. The terms that are used in topic 1 represent ca. 33% of the terms (tokens) used in the reviews. The percentage assigned to this topic means the proportion of the terms regarding this topic in the entire text of the reviews. The more important the term to the specific topic, the higher it is positioned in the bar diagram. The example of the bar diagram and the ranking of the terms in accordance with the estimated term frequency within a selected topic, which is number 1 in this case, is presented below in Figure 16.

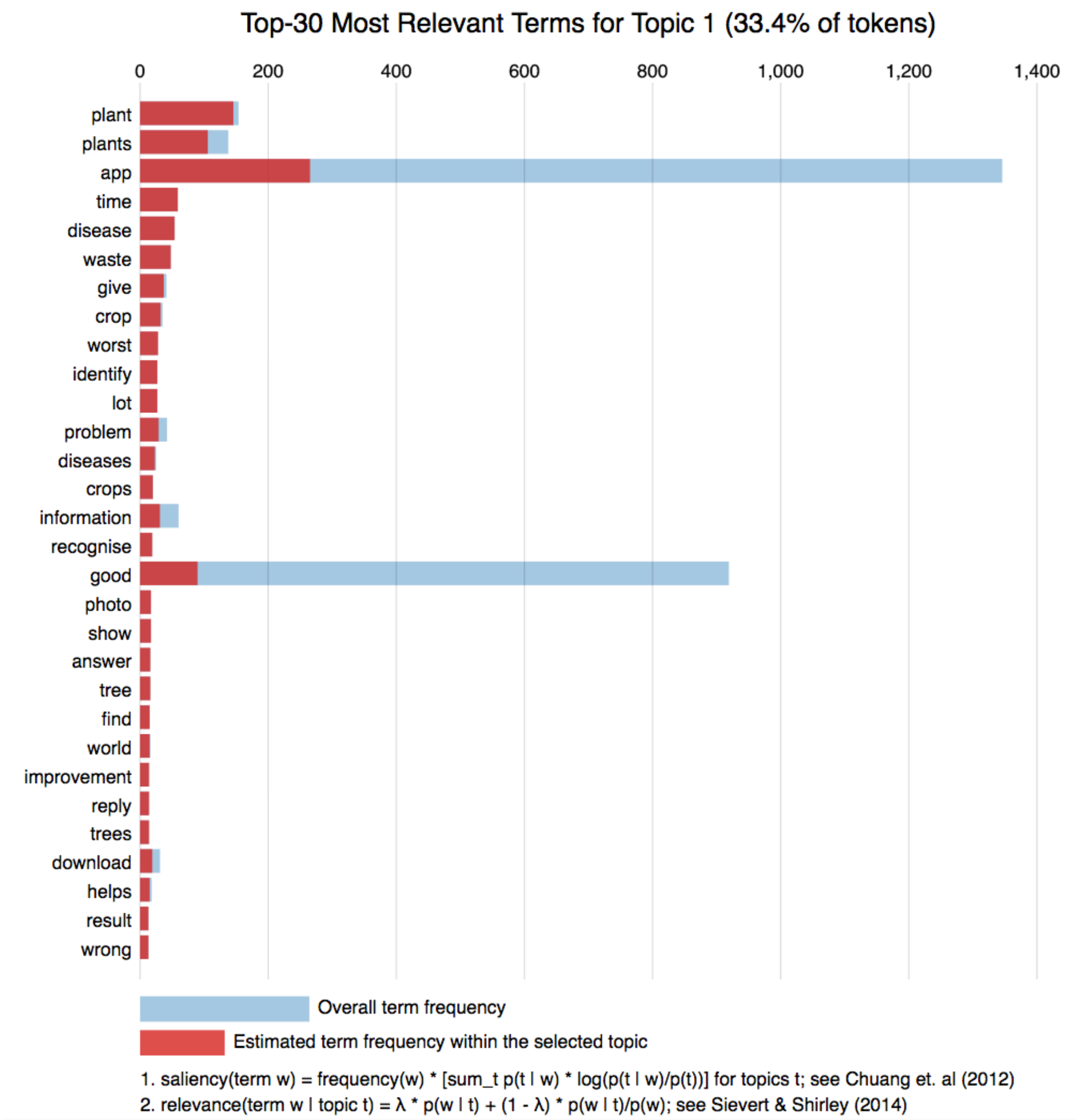


Figure 16: The most frequent terms used in topic number 1 visualized with LDAvis

The topic cluster that combines **topics number 2, 3 and 5** reveals the farmers' estimation of the three different aspects connected with the app, where the most commonly used terms are "good, great, nice, awesome, helpful".

Topic number 2 praises the team who created the app Plantix and their job. "agriculture, knowledge, nature, gardening, environment" are the areas where the app has a positive impact **according to topic number 3**.

Topic number 5 contains such terms as "nice, super, good, excellent, bad" addressed directly to the app. **Topic number 4** shows the aspects of the importance of the language used in the app. The following terms are characterized by this topic: "language, india, hindu, add, kannada, telugu, tamil" – all these are dialects in India and, apparently, the farmers would like to have the app in those languages, too.

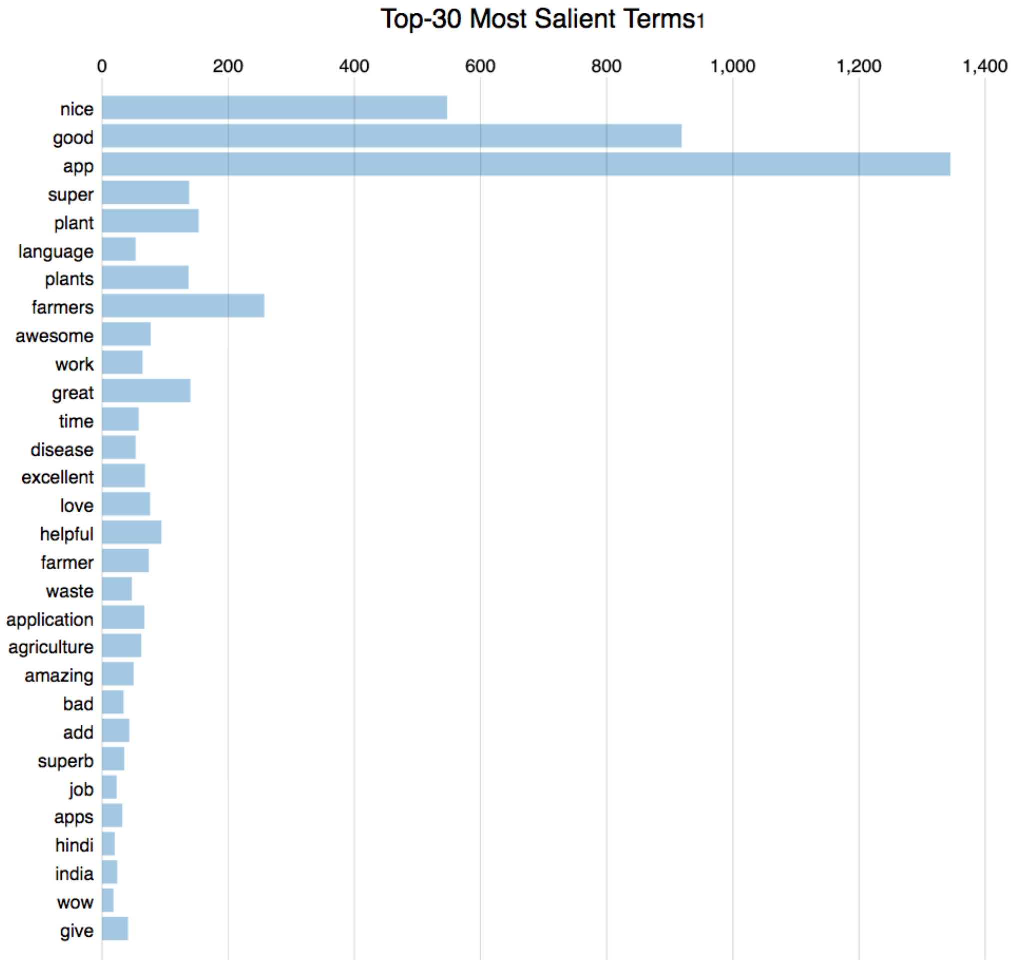


Figure 17: The top-30 most frequent terms in the overall reviews visualized with LDAvis

The graph above demonstrates the top 30 terms that appear most frequently in all reviews in English, independent of the topic. Among them the top five are "nice, good, app, super, farmers". The frequency of the words can be seen on the bar graph below; the more often the word is used in the reviews, the longer the bar. This means that, in general, most of the reviews are positive and that the farmers are satisfied with the app and that it apparently provides feasible advantages in the recognition of plant diseases, which supports hypothesis number one.

In a further step, the positive feedback was analyzed. To do so, reviews with 4 or 5 stars were filtered. Positive reviews comprised approximately 80% of all reviews in English. The share of positive reviews shows that the users were generally satisfied with the service the app delivered. To give the model a concrete shape, both 5 and 10 topics were tested. It was determined that 5 topics were best suited to summarize the positive reviews.

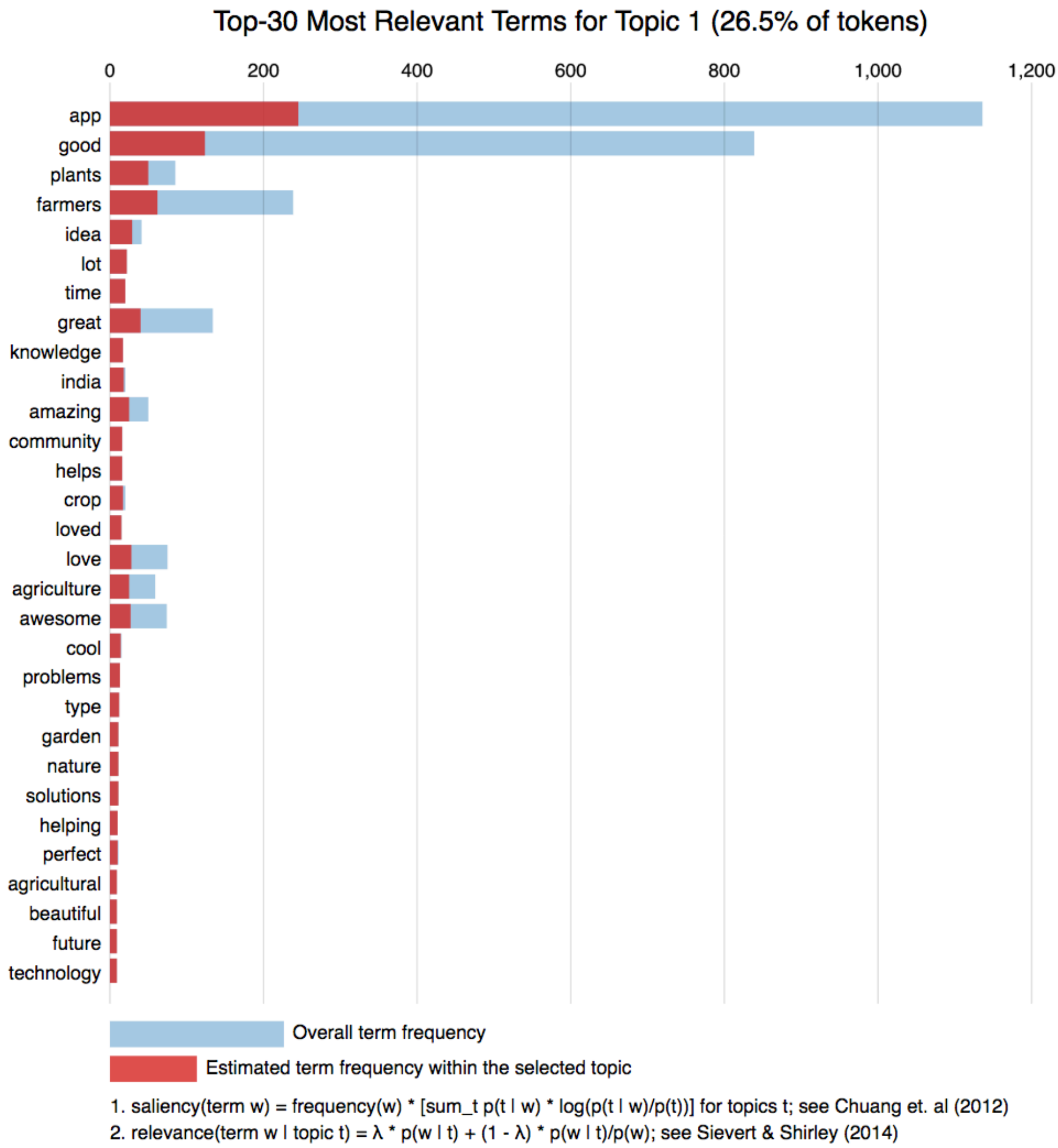


Figure 18: The most frequent terms found in topic number 1 in the positive reviews of the Plantix app in English, visualized with LDAvis

Topic number 1 is the largest of the 5 topics and contains 26.5% of tokens (terms) from the positive reviews; that is why the top 30 terms found there are presented above in Figure 18. According to the top 30 most relevant terms in topic number 1, the users appreciate the app itself, the idea behind it, the knowledge they receive via the app, and the community that helps solve their problems. Since most of the customers using the app, according to the analytics platform sensortower.com, come from India (80%), the term “India” is also one of the most commonly used in the reviews.

Topic number 2 includes the top terms about the plant disease identification function and the language. The proportion of tokens in this topic is also more than 20% in the corpus of positive reviews. **Topics number 3 and 4** have many positive descriptive terms such as “good, helpful, amazing and awesome”. In the topic number 3, those adjectives refer to the job or work that Plantix does. In the topic number 4, these terms are connected to the learning and information that farmers receive through the app. **Topic number 5** contains many descriptive positive terms like “nice, good, superb, happy” that refer to the app[18].

According to the positive reviews analyses in English, the users appreciate the main function of the app that helps identify plant diseases, as well as the knowledge and community support that it additionally provides.

Although the positive reviews represent the largest part of the evaluation, there are still 20% of the users that had several issues with the app. The negative reviews received 1 or 2 stars from users. After trying different combinations of topics, 3, 4, 5 and 6 remained. The most suitable number of topics for describing the negative reviews was 6.

Topics number 1 and 2 contain the terms that were mentioned most frequently in the reviews in comparison to the others. There is a cluster of 3 topics, including those most often mentioned, which means the negative reviews have something in common.

[18] The visualised topic-modeling is in Annex 8.5

As the graph below shows, the most frequent terms **in topic number 1** concern not finding information about the plant or not identifying it correctly.

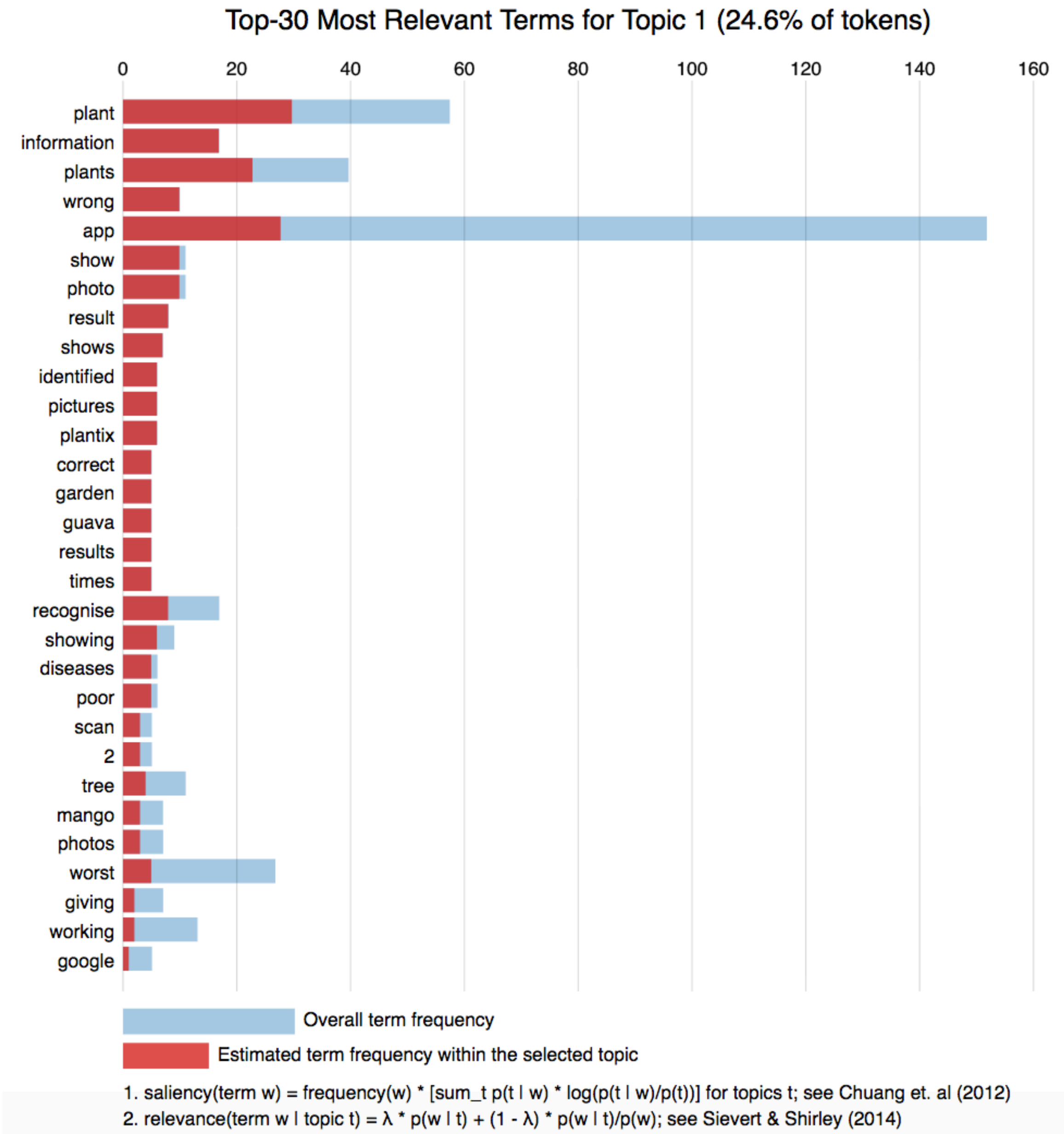


Figure 19: The most frequent terms in topic number 1 appearing in the negative reviews of the Plantix app in English visualized with LDAvis

In topic number 2, the most frequent terms were also about the problems with the plant and disease identification. Apparently, especially guava and mango were often not properly recognized by the app.

In topic number 3, the users were not satisfied with the solution suggested by the app. **Topic number 4** was about language; the Kannada language was mentioned especially frequently; apparently, some of the users understand it better than Hindu. The terms of **topic number 5** were just generally describing that the app was not working, and the users were feeling that they had wasted their time. And finally, the last **topic, number 6**, concerned problems with the login and sign-in process.

In line with the negative reviews in English, it is possible to conclude that although the plant image recognition generally works in most of the cases, the algorithm is still not perfect. Some users were extremely frustrated whenever the plant was not properly identified. As a result, the solution was also not correctly recommended. Language also plays very important role for the users. There is a trend that indicates that the Kannada language should be the next to be implemented.

According to the majority of the English reviews, the app is fulfilling its promises to the users, i.e. identifying the plants' diseases and offering a correct solution. However, the process is still not working perfectly; some users still have problems finding the right diagnosis. The most commonly used terms in the reviews were "good, awesome, helpful, superb", which positively describes the perceived usefulness of the technology. Since the present study was focused on Germany, in the following section, the reviews in German will also be analyzed and compared to the ones in English.

5.5.3.1.2 User's perception based on the reviews in German

The statistics of sensortower.com, shows that only 3% of the app users are in Germany. For the analysis, 129 reviews in German were identified. To start an analysis of the German reviews, the same data cleaning procedure was performed as with the reviews in English.

According to Table 17 (presented below), the minimal length of a review In German was 4 characters, and the longest review had 640 characters. 86 reviews were positive and 33 were negative. The positive reviews were shorter in comparison to the negative ones. The average length of the German reviews was twice as long as their English counterparts. However, the longest review was given in English; it was positive, whereas the longest review in German was a negative one.

Parameter	All reviews	Positive reviews	Negative reviews
Min. review length	4	4	8
Max. review length	640	303	640
Average review length	106	97	106
Median review length	77	77	66

Table 17: Statistical parameters of the review length (in characters) in German

For the topic-modeling of the reviews in German the number of topics was set at 5. The Top-30 frequent terms in all the reviews include the following: “pflanzen” (plants), “foto” (photo), “tolle” (great), “hilfreich” (helpful), “gut” (good), “schnell” (“fast”), “funktioniert” (functions), “geht” (in this context, it means that it works), “tipps” (advice), “einfach” (easy), “idee” (idea), “garten” (garden), “obst” (fruits), “gemuese” (vegetables), “gartenbank” (the old name of the Plantx app), “erkannt” (identified). There are three bigger topics and two smaller ones. There is one topic cluster that contains two relatively big topics (topics number 1 and 3).

The terms that characterize these topic-clusters (topics number 1 and 3) describe the functionality of the app. The most frequent terms include “works, identifies, plants, garden vegetables, fruits, easy, good”. In Figure 20 below the most frequent terms in **topic number 1** are presented which have the highest portion of terms in the reviews in German.

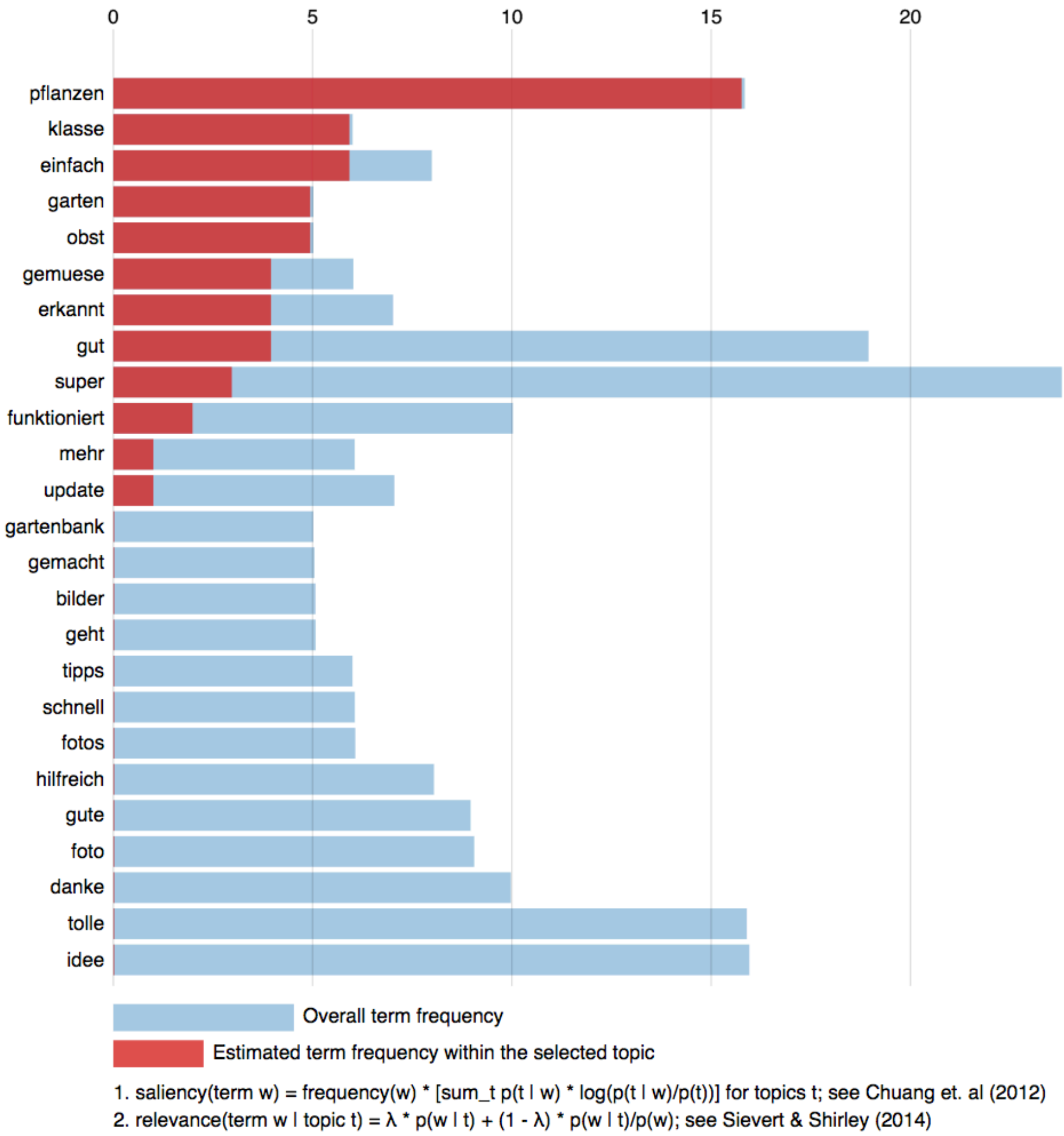


Figure 20: The most frequent terms found in topic number 1 in the reviews of the Plantix app in German visualized with LDAvis

In topic number 2, the most commonly used terms are positive adjectives such as “good” and “super”, which refer to the idea and advice received. **Topic number 4** describes the experience while using the app. The main terms are “helpful, fast, super, thank you, good, easy, idea, vegetables”. **Topic number 5** is about the positive experience of taking a picture of a plant with a disease.

The next step is to take a precise look at the positive and the negative reviews and to identify the differences regarding app perception.

For the topic-modeling of the positive reviews, the number of the iterations was the same; the number of topics was set to 3. The top terms in all reviews were “tolle” (great), “pflanzen” (plants), “super”, ”hilfreich” (helpful), “gut” (good), “einfach” (easy), “klasse” (great), “gartenbank” (old name of the plantix app), “idee” (idea), “danke” (thank you), “funktioniert” (works), “tipps” (advice). Out of the three topics, topic number 1 seems to contain the most frequently used terms and has a proportion of 44.6% of all tokens.

The most relevant terms for that topic address two aspects: the idea and advice that the users receive via the app. The adjectives most frequently used in this topic characterize a good experience and the appreciation of the app. The relevant terms from **topic number 2** describe the idea of the app as being “helpful, easy, good” and that it “works”. The top frequent terms of **topic number 3** indicate that the tips provided by the app work well and seem to be good.

For the negative reviews, the number of the topics was also set to three. The top four most frequent terms are “foto” (picture), “pflanzen” (plants), “update”, “funktioniert” (works) according to the graphic below.

Topic number 1 is characterized mostly by the terms “update” and “funktioniert” (works). This could mean that apparently, after the app updates, some users have problems with using it. **Topics number 2 and 3** are mainly characterized by one term: “picture” regarding the second topic and “plants” regarding the third topic. These terms indicate that the users sometimes have problems with the picture, either with the identification or whilst uploading and, regarding the third topic, it could mean that the app could not recognize the plant.

The reviews in German and English both showed that most users perceive the plant recognition and treatment recommendations as helpful and good. This means that the advantages of the app written in the press kit about the Plantix app are recognized and positively embraced by the users. Although there are still some issues with plant recognition, and some farmers would like to have certain additional plants in the app, the majority of users rated the app positively. The language topic was important for the reviewers who wrote in English and used the app in India.

5.5.3.2 Trial version, API and development of the Plantix app

Since the app delivers the promised features in the eyes of most users and provides a feasible advantage, it is also important to see if it is possible to have a trial version of it. Trialability is one of the most important characteristics of innovation that supports adoption, according to Rogers (1983). The Plantix app is free to download and there are no built-in paid functions.

Keeping the app free of charge is one of the most important aims, according to the co-founder of PEAT, Pierre Munzel. In the in-depth interview, he describes that the app could be financed in cooperation with international or state organizations, e.g. the German Corporation for International Cooperation, or by selling an API license to agricultural corporations.

One of the important issues the EIP-AGRI (2015) suggested in the expert report was the lack of opportunity to integrate new precision farming tools into those already existing. This aspect of the technology also influences ease of use and usefulness. From the very beginning, PEAT has developed its software so that it would be possible to integrate other systems into it (Start-Green, 2018). On the one hand, the API allows third parties to use the PEAT technology in their software; on the other hand, it allows PEAT to easily integrate additional functions to their software.

API for PEAT also represents an additional business model, through which companies can integrate the functions of the PEAT software for a license fee. This business model was successful in Germany, where companies that produce plant protection remedies became interested in the machine learning algorithm for plant disease recognition, according to the in-depth interview. Instead of developing their own algorithm system, the companies pay a license fee and, at the same time, also provide photos for new plants in order to train the system. Thus, PEAT can constantly broaden its database of plant diseases and, at the same time, their technology can reach additional users without additional marketing costs.

According to the in-depth interview with one of PEAT's co-founders, Pierre Munzel, while developing their first version of the Plantix app (initially called "GartenBank"), friends and acquaintances became their early adopters.

"We invited our friends and acquaintances to our beta-group. There was a total of 100 participants in the group who tested the app and provided us with the feedback about its usability." - from the in-depth interview with the co-founder

To train the image-recognition algorithm, PEAT started a crowdsourcing-science project in 2015 that was open to any participants and aimed to collect as many photos of the plants as possible, as Mel (2015) reports in her blog. The hobby gardeners and farmers could use the first version of the app not only to find photos of plant diseases but also to take their own and upload them to the app. Those images were then collected, analyzed and categorized. As a result, more than 6,000 images were obtained during this project.

5.5.3.3 Target group and cooperation as key marketing strategies

According to Moore (1999), one of the possible ways to avoid a chasm on the market is to concentrate on a niche. One of the possible niches on the agricultural market are large farms. However, for PEAT this segment of the market was not a main interest from the very beginning. Instead, as a target-group, hobby gardeners and small farmers were selected. According to the in-depth interview with the co-founder of the Plantix app, especially small farmers in developing countries do not have the resources to purchase expensive software to monitor their farm but, at the same time, they also have a substantial need for solutions to be able to save their harvest and to get expertise which otherwise is not easily available.

So how did PEAT manage to grow so quickly in such a complicated segment of the market, while often small farmers are not the ones who adopt new technology in the first place? What kind of marketing strategies did the startup use? First, the partners of the PEAT startup will be looked at. To find an answer to this question, the in-depth interview and online articles will be analyzed.

In 2017, PEAT received several important awards, e.g. the CEBIT Innovation, the World Summit Award (United Nations) in the category Environment and Green Energy (WSA, 2016), and the Global Data-Driven Farming Prize by the US government's Feed the Future Initiative (Jackiewicz, 2017). These awards helped the startup direct attention to their technology.

Since 2016, the founders have been looking for strategic partners to launch the app in Brazil, India and Mali, according to the in-depth interview with a co-founder. In May of 2017, PEAT officially launched the Plantix app in India in cooperation with International Crops Research Institute for the Semi-Arid tropics (ICRISAT) and the Acharya N G Ranga Agricultural University in Vijayawada (ICRISAT, 2017). ICRISAT also has additional regional centers in Mali and Kenya and research stations in Niger, Nigeria, Malawi, Ethiopia and Zimbabwe. In India, ICRISAT has even gained special status as a UN Organization. The app was launched in two languages: in Hindu and in the local language, Telugu. ICRISAT organized several workshops for the field managers and plant disease experts to test and show how Plantix works, according to PEAT's social media platforms. The aim of the cooperation is to "build a database of pest and disease images and content for its six mandate crops" (ICRISAT, 2017). A special team in the ICRISAT- Integrated Crop Management supports the startup in collecting the relevant plant diseases in India, as well as solutions for treatment of those diseases.

Another international project involving the startup is called "The Feed the Future Nepal Seed and Fertilizer" (NSAF). This project is supported by the United States Agency for International Development in Nepal. The project started in April of 2016 and will end in March of 2021. The aim of the cooperation between PEAT and NSAF is, on the one hand, to translate the app into Nepali and to adapt it to the major agro-ecologies of the country; on the other hand, it aims to develop a crop calendar app. The app should "integrate all of the outputs of the collaborative agronomy programs of NSAF and NARC (variety recommendations, soil data, fertilizer recommendations, etc.) into an interactive advisory guide for farmers" (USAID, 2017, p.6).

The German Corporation for International Cooperation (GIZ) also took part in a joint project with the startup in 2016. The Plantix app was a part of two programs: „Promoting Sustainable Agriculture and Rural development" and the „Green Innovation Center" in Tunisia, which should help female smallholder farmers to gain access to knowledge about plant diseases. To achieve this aim, female farmers were provided with smartphones and were technically and economically trained to later act as local service providers called "plant doctors", by using the Plantix app. For the project, 70 participants who had 6 days of training with the Tunisian plant-experts were selected. The Plantix app was then later presented and promoted during several events, conferences and at one of the largest agricultural fairs in Africa (GIZ, 2018).

The Centre for Agriculture and Bioscience International (CABI) is another cooperation partner of the PEAT startup. The aim of the organization, according to its website, is to provide information and scientific expertise to solve agricultural and environmental problems. This non-profit organization partnered with PEAT as part of an 18-month study "to assess the benefits of a smartphone app called Plantix" (CABI, 2018). The partnership aims at improving the app's disease detection ability and integration of biologically based pest management. The scientists of the MS Swaminathan Research Foundation in Tamil Nadu, India, and plant doctors will test the app on rice, groundnuts, brinjal, chili peppers and bananas.

These international, non-governmental organizations are the main partners of the startup in terms of farmers' education and app promotion. At the same time, these partners are customers who help develop the app, suggest additional functions (like the NSAF cooperation did) or improve existing functions by testing them with the farmers and extension agents. Moreover, releasing Plantix in a new country means finding new partners and experts who can help introduce new types of crops and diseases that are specific to a certain country into the database. Those partnerships are essential to the startup because in order to include a new crop, a certain number of photos showing possible new diseases are needed to be able to train the algorithm to recognize those diseases shown on the photo. Since the diseases are new, in addition to their recognition, new treatments also need to be developed.

5.5.3.4 Mass media as important source of growth

Another important source of growth for PEAT was the press. When the first version of the app “GartenBank” was introduced, an article in a local Hannover newspaper was promptly published. This article caught the attention of a regional TV channel. This TV channel made a video for a popular show called “NDR Markt”. After the report about the app was streamed during the show, the number of downloads grew exponentially and, according to the in-depth interview with the co-founder, the press is still one of the most important sources for growth.

To analyze press coverage about the app, all articles about the app and the PEAT startup were collected. As a source, Google-Search was used, applying the keywords “plantix, peat startup” in German and English. Also, all the articles that are mentioned on the startup’s website were used. On 22 August 2018, the keyword plantix could be found on 25 pages on Google. Some articles were also displayed in other languages, e.g. French, Russian, etc. These articles were not used for the analysis.

14 Google pages with the keyword “peat startup” were reviewed, as on the further pages there was no information connected to the startup. To analyze the content of the articles, the LDAvis model was used. To prepare the articles for analysis, the same procedure as for the review analysis was applied. The number of iterations for the model is 5,000. In total, 48 articles in English and 53 in German about PEAT and the Plantix app, including the Wikipedia description, were analyzed[19]. The articles about PEAT appeared in well-established mass media sources that have a significant number of readers worldwide, such as Fortune, Wired, Deutsche Welle, Euronews, Al Jazeera, BBC.

[19] All articles used for the topic modeling presented in Annex 8.6

For the analysis of the articles written in English, the following number of topics were tested: 30, 20, 10, 8 and 5. The most suitable number of topics for the description of the articles was 5. Two topics were more frequently mentioned in the articles than 3 others.

Topic number 1 was characterized by such terms as “app, plant, peat crop, disease, pests, mobile, based, companies, treatment”. This topic could be characterized as a problem statement that the app tries to solve. Such terms as “worldwide, countries, brazil, collaboration” also appear in this topic. This means that the problem of the plant diseases the company wants to solve worldwide and collaboration also play their roles in the achievement of this aim.

Topic number 2 top ten terms are “farmers, plantix, agricultural, startup, learning, plants, technology, image, Indian, identify”. This topic could be described as a technology description and the target group. Apparently, the greatest number of articles in English referred to the Indian market and the use of the app there. **Topic number 3** had as most frequent terms such words as “diseases, india, users, germany, company, nutrient, pest, local”. This topic could be described as the importance of Indian users for the German company and its solution for fighting plant diseases. **Topic number 4** concerns the technological aspects of the app and is characterized by such terms as “database, recognition, knowledge, digital, smartphone, ai, algorithms, smart”. **Topic number 5** could be described as the role of this technology in environmental control for farmers.

Among the top terms are “information, pictures, developed, data, technologies, farmer, picture, food, environmental, control, detection”. Below in Figure 21 the 30 most frequent terms in all the articles in English are shown.

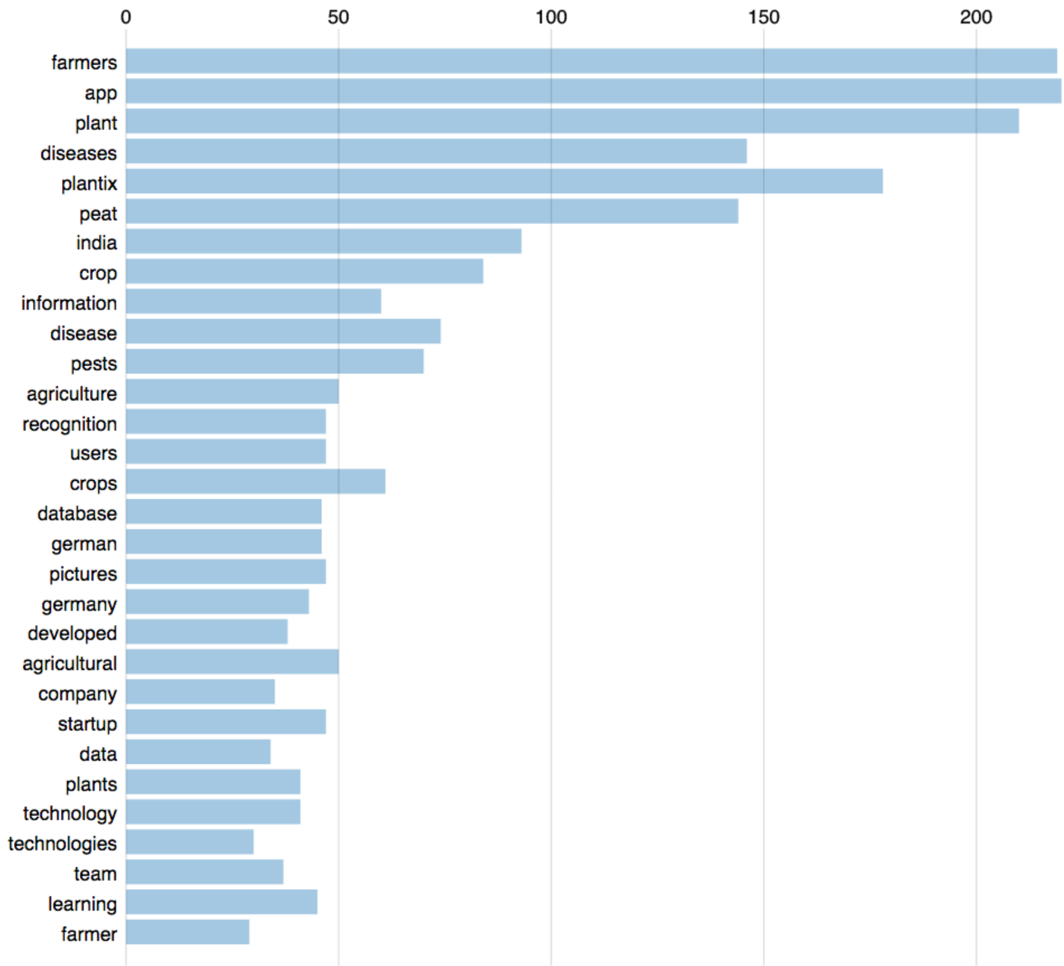


Figure 21: The most frequent terms used in the articles in English visualized with LDAvis

For the analysis of the articles in German, the number of topics was set first to 15, then to 10, 7,5 and 3. The most suitable number of topics for the description was 3. The top ten most used terms in German articles were “plantix, peat, software, pflanzen (plants), krankheiten (diseases), erkennen (identify), pflanzenkrankheiten (plant diseases), nutzer (users) weltweit (all around the world), bauern (farmers)”. The graph below shows the most frequent terms in the German articles.

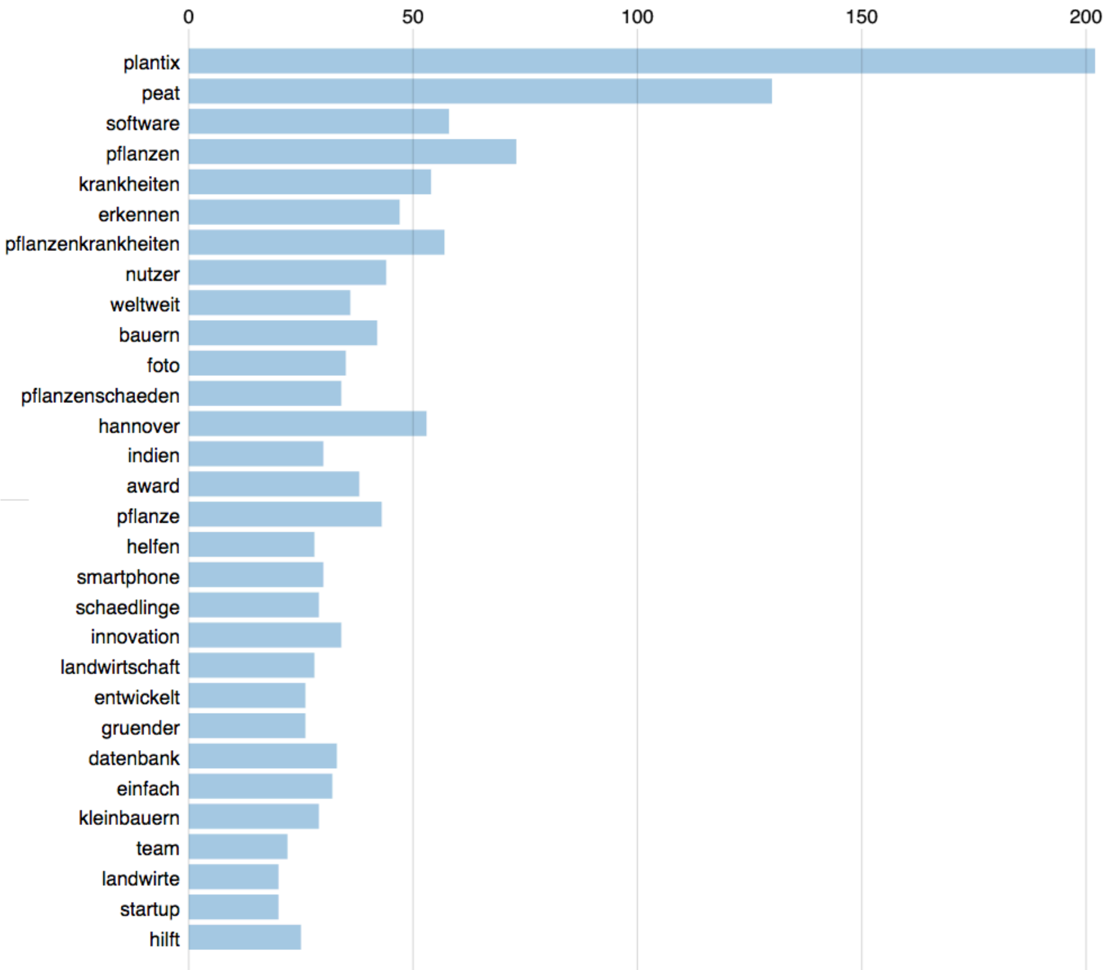


Figure 22: The most frequent terms used in articles in German visualized with LDAvis

Among the three topics identified in the German articles, **topic number 1** could be described as an innovative solution for the farmers. The most frequently used terms in this topic are nearly the same as those listed above except new ones like award, innovation and cebit. Apparently some of the articles in German were written about the CeBIT award for innovative technologies, which the startup received in 2016. **Topic number 2** refers to the internationalization of plant disease recognition technology and the possibility to use it worldwide, especially in Brazil. Among the top 15 terms in this topic are „weltweit" (worldwide), „schaedlinge" (pests), „brasilien" (Brazil).

Topic number 3 has a focus on another country - the role of the founders of the app for Indian farmers. This topic is a combination of the terms referring to some special features of the technology such as algorithms, diagnosis, and treatment, which are the core functions of the app. Apparently in some articles there was more information about the founders and the idea generally, which is why there are such frequent terms as Hanover, the city where the startup was founded; team, founders (in German "greunder"), idea (in German "idee").

According to the topic-modeling presented above, the articles in English about the app were more concentrated on the description of the value and technological aspects of the app, as well as the impact it might have on the farmers and its marketing strategy to expand through collaboration. The geographical articles in English referred to three countries: Germany, India and Brazil.

In the German articles, in addition to the technological aspects of the app and its target group, the technology was described as a distinctive innovation. Brazil as another important country for this technology where the idea of it was born was also mentioned. The German articles also paid more attention to the founding team, confirmed by such frequent terms as the founding city "Hanover", "founder", "team", "idea". Another trigger in the German press for the articles was an innovative award granted to PEAT by the CeBit technology trade fair. In general the press articles described the benefits of the app, which could serve as a trigger for the decision to adopt.

The present case study revealed the special role that international organizations play in the marketing strategy of the startup PEAT. They enable a startup to enter new markets by providing the necessary data about the plants and treatments, training for the farmers and sometimes even financial resources for the development of new features. The CeBit award provided this startup with the necessary attention to their innovative technology and through this award provided PEAT with the first interested agricultural corporations, as well as some international cooperation partners. The press coverage also helped to find new users, as well as gain more trust in the eyes of the potential cooperation partners. According to the reviews of the Plantix app the users were satisfied with its services. The most mentioned topic in German and in English was the recognition of certain plants and plant diseases. In English reviews the language was also important and there is a trend that indicates that the Kannada language could be the next to be implemented.

6 Conclusion

Make the feeding of the livestock healthier, reduce feed costs and improve feed efficiency; save money on more efficient crop protection and reduce overall use of pesticides; recover up to 30% of the harvest due to intelligent plant disease analysis: these are examples of the objectives that new agricultural startups want to achieve using such technologies as artificial intelligence, the Internet, sensors, etc. Reaching these objectives and distributing these technologies among farmers plays an important role in the increase of food production and its quality, which must be achieved by 2050, according to the Food and Agricultural Organization (FAO, 2009).

However, according to the expert focus group EIP-AGRI (2015), the process of the diffusion of these innovations in the European countries is much slower than expected. Therefore, the purpose of this investigative work was to discover what kinds of obstacles exist on the market, and what strategies agricultural startups apply to overcome them to be able to achieve critical mass on the market. To identify the marketing strategies for the achievement of critical mass, two qualitative inquiries (in-depth interviews and a case study) were conducted. The results of those two inquiries provided certain insights that might be helpful for startups on the way to achievement of critical mass. In addition to simply giving some practical advice, the research presented here could provide insights which might lead to a theoretical adjustment of the channels that could be used to achieve critical mass on the market where a chasm exists.

6.1 Recommendations for agricultural startups to achieve critical mass

The qualitative investigation of various types of agricultural startups helped to reveal seven common strategies that startups with critical mass were following. It is possible to divide the strategies discovered through the interviews and the case study into two major categories: technological aspects that a service or a product should have and specific channels that worked the best to attract early adopters within a short time. The table below provides an overview of those strategies. These strategies are not a recipe for success, but they were something most of the startups interviewed had in common and could be considered as a recommendation or a basis that might be helpful to achieve continued growth.

Technological aspects	Customer channels
feasible technological advantage	mass media
joint product development	cooperation for educational purposes
trial version	cooperation for distribution purposes
API	

Table 18: Marketing strategies of the startups with critical mass

The technological aspects mentioned here aim at the product itself and certain characteristics connected with it, such as feasible advantage. The role of each of the four aspects -- feasible technological advantage, joint product development, trial version and API – is different during the initial phase of development. Some startups started with one idea of the product and developed a first version to provide a trial opportunity to the first users. This enabled them to discover technical bugs and at the same time better understand if the product or service provided enough value and if not, to adjust it as soon as possible. Some startups started with their own observations of the work process on the farms and interviewed the farmers before they developed their first version of a product/ service. Others collaborated with the farmers in order to create a better user experience. But independent of the time when the joint development took place or a trial version was presented, in the end, the only thing that counted from the perspective of the farmer was the real feasible technological advantage of adopting a product/service. In any case, startups with critical mass used both joint product development and trial versions as strategies to find feasible advantages to offer to the farmers. Development of the API often took place at the end of the product testing phase and served as a bridge for further growth in cooperation with other existing services on the market.

Customer channel strategies represent the most useful means of communication to find and to win over early adopters. All startups with critical mass used mass media actively and could gain significant growth through specific newspapers or TV programs within a short time. However, the growth was not sustainable. The most efficient and sustainable growth channel which most of the startups aim to achieve is word-of-mouth. The difficulty of this channel is that it requires trust and personal communication that is difficult to achieve en masse due to the limited budgets of the startups. To overcome both of these barriers, startups with critical mass found partners who had already gained trust from farmers and who usually communicate with them at regular intervals. In the case of the startups investigated, such partners were either distributors or NGOs that work actively with farmers.

Recognition of the technology potential of the Berlin startup PEAT by the United Nations helped them to build international cooperations with agricultural institutions in other countries. The Indonesian president's personal interest in agricultural technologies influenced the growth rate of one of the startups interviewed. These examples reveal the positive role that trusted governmental institutions could play in the process of gaining sustainable attention on the market that most startups lack, as they are relatively unknown. Educational programs for the farmers where startups could test their technologies together with the target group could help to spur the adoption rate of the most important solutions in the sector. According to the interviews, in some countries, e,g, India, such educational roles are either fulfilled by NGOs or other research institutions. Often such educational programs are financially supported either by the government or by such international organizations as the United Nations, GIZ or USAID. Such joint programs could play an important role for the startups which are developing solutions for the markets with chasms due to the technological knowledge gap between early adopters and the early majority.

6.2 Implications for the diffusion of innovation theory and further research

In the diffusion of innovation theory, the phenomenon of innovation adoption is defined as a process where information about innovation is communicated or diffuses through a social system (Rogers, 1983). Communication of information about new technology provides knowledge about innovation and reduces uncertainty about its benefits and risks (Rogers, 1983). The communication process generally takes place through two main channels: mass media and interpersonal channels. According to Mahajan *et al.* (1990), before critical mass is achieved, the main communication channel is mass media. As soon as critical mass has been achieved, the role of mass media in the further diffusion process decreases and interpersonal communication increases.

However, what happens if there is a gap between the early adopters and early majority on the market? Which channels should be used to allow further growth? According to the results of the in-depth interviews and the case study, the relevance of interpersonal channels in this situation increases before critical mass is reached.

According to the in-depth interviews, one of the main obstacles on the market that startups and farmers identified was a lack of demonstrability regarding the new digital technologies and their impact on the farming process. As a result, the most effective channel for customer acquisition for all the startups that participated in the in-depth interview was direct contact. Some startups could observe that, after they visited one or several farmers in certain regions, the farms in the neighborhood started using their technology after a short time. Cold calling was also one of the most frequently used methods among the online marketplaces at the beginning according to the telephone interviews.

The case study showed that the market entrance for PEAT in India and further developing countries was possible only due to numerous cooperations. In the course of those cooperations, several workshops were organized to teach change agents or selected farmers about the use of the technology. According to the application's website reviews, the workshop participants began using the PEAT solution and working as disseminators for other farmers.

These insights from the qualitative investigations indicate that startups have recognized that the best channel for sustainable technology adoption in the farming sector is interpersonal contact. This observation was made by all startups interviewed, including those that have not reached critical mass. This contradicts the general theory, which claims that the role of mass media should be the best suited channel for achievement of critical mass at first, and then only with the achievement of critical mass the role of word-of-mouth increases. The theory, however, does not specifically consider markets with chasms between early adopters and the early majority. It is important for further application of this theory to investigate if the interpersonal channel has a greater impact on adoption before achievement of critical mass only on the markets with chasms or if this theory should be reconsidered in general.

Due to the relative newness of the agritech sector there is still only a small number of startups developing certain technologies, which is why the main investigative method was qualitative. Nevertheless, the sector shows impressive growth rates attracting more and more entrepreneurs. As a result it could be interesting for further research to test the hypotheses developed here quantitatively. The advantage of a further quantitive investigation is the estimation of the exact impact of each type of strategy on the startup's growth, which is hard to define using the qualitative method. Therefore, one can discover the strategy combinations that make most sense for startups. This could be one of the possible directions for further research.

Another interesting research direction could be a detailed investigation of different types of partnership that can take different forms and involve different types of players and their impact on growth. Some studies have already done this for various industries. It would be interesting to find out what types of partnerships play a crucial role for technology diffusion in the agricultural sector.

A further promising area of research is an investigation of the communication channels on the markets where the chasm between early adopters and the early majority exists. If the assumption that interpersonal channels are pivotal for the diffusion of innovation could be supported by the quantitative data, then it could provide an essential insight for all the companies that work on such markets and wish to develop new products. Moreover, the existence of the chasm on the agricultural market was only indirectly confirmed by the studies about innovation adopters and the results of the in-depth interview. The quantitative investigation of the exact factors influencing the chasm on the agricultural market could also be helpful in optimizing marketing strategies for companies which are considering launching a new technology and improving the product according to the needs of the early majority.

7 Summary

According to the report of the Food and Agriculture Organization of the United Nations, due to population growth, food production must increase by 70% by 2050 to meet rising demand (FAO, 2009). Digital agricultural startups are one of the main players on the market who develop innovations which should assist in accomplishing this task. However, most of the startups fail during first three years without achieving critical mass. To understand what kind of obstacles exist on the market and what marketing strategies might help in overcoming them, 11 in-depth interviews with international digital startups from developed and developing countries were conducted. The results of the interviews were verified with help of data triangulation. A low frequency of IT use, a lack of software compatibility and result demonstrability, as well as a general lack of trust due to the newness of the company were the main challenges that the startups interviewed faced. To overcome the technological issues, startups involved potential customers in the developmental phase. To demonstrate the results of the solution and win the farmers' trust, startups sought direct contact to the farmers via fairs or other types of events. Some startups used cooperation for educational and distributional aims to increase the interpersonal communication and to improve their reputation among farmers.

In the next step, the results of the in-depth interviews combined with the theory about the innovation acceptance and the expert opinion of EIP-AGRI (2015) were turned into hypotheses about the marketing strategies that lead to achievement of critical mass on the agricultural market. To verify the hypotheses, German farm management information system startups were selected. According to the Gartner's Hype Cycle, farm management information systems are a mature form of technology that could be adopted by the mainstream market. Moreover, this type of technology is one element of precision farming that is actively promoted in the EU (EIP-AGRI, 2015). However, the diffusion of this innovation is lagging, so the importance of finding a way to achieve critical mass could be essential for further adoption. Since only 10 existing farm management startups matched the selection criteria and only 7 of them agreed to participate in the research, a telephone interview based on a structural questionnaire was carried out. The marketing strategies from the telephone interviews were triangulated with the marketing strategies of 9 German online marketplaces. Both the online marketplaces and the farm management information systems improve the value chain in the agricultural field and both technologies use wireless connections to fulfill their functions. According to the results, all the companies with critical mass took the technical aspects of the technology seriously and offered feasible advantages, trial versions, the possibility of the integration of their functions into other products or data sharing, as well as joint testing of their solution with farmers. The use of mass media as a relevant communication channel is also something common to all the companies. Cooperation for distributional purposes was a strategy that the majority of the companies with critical mass followed.

Among the farm management information system startups, PEAT had an extraordinary growth rate, not only in Germany but also in India, Nepal and in Tunisia. To explore what kinds of strategies contributed to such growth, a case study about this startup was conducted. The case study revealed a special role that international organizations play in the growth strategy of the PEAT startup. They enable a startup to enter new markets by providing the necessary data about plant diseases and their treatment, training for the farmers and sometimes even financial resources for the development of new features. The CeBit award provided this startup with the necessary attention to the technology that they had developed and thus provided it with the first agricultural corporations interested in their products/applications, as well as with some international cooperation partners.

The results of the qualitative investigation into the marketing strategies of digital agricultural startups demonstrated an important role of the technological aspects such as API and usability of innovation, as well as interpersonal communication for the achievement of critical mass. Since the number of startups selected for the research presented here was small, it would be interesting to verify the results obtained with a larger number of startups when the opportunity occurs.

8 Literature

AgFunder (2017): AgriFood Tech Investing Report. Retrieved from https://agfunder.com/research/agrifood-tech-investing-report-2017 (04.12.2018)

AgGateway (2017): Data Privacy and Use White Paper. Retrieved from https://s3.amazonaws.com/aggateway_public/AgGatewayWeb/WorkingGroups/Committees/DataPrivacySecurityCommittee/2017-03-31 Data Privacy and Use White Paper - 1.2.pdf (04.12.2018)

Aguilar-Gallegos, N., Rodríguez, M. M., Santoyo, H., Jorge A. A., Klerkx, L. (2015): Information networks that generate economic value: A study on clusters of adopters of new or improved technologies and practices among oil palm growers in Mexico. Agricultural Systems, 135, pp.122-132.

Ajzen, I. (1985): From Intentions to Actions: A Theory of Planned Behavior. Action Control, pp. 11-39.

Ajzen, I. (1991): The theory of planned behavior. Organizational Behavior and Human Decision Processes 50 (2), pp. 179–211.

Alambaigi, A., Ahangari, I. (2016): Technology Acceptance Model (TAM) As a Predictor Model for Explaining Agricultural Experts Behavior in Acceptance of ICT. International Journal of Agricultural Management and Development, 6(2), pp. 235-247.

Albert, T. (2015): Measuring technology maturity: Operationalizing information from patents, scientific publications, and the web. Wiesbaden: Springer.

Alshenqeeti, H. (2014): Interviewing as a Data Collection Method: A Critical Review. English Linguistics Research, 3(1), pp. 39-45.

Anthony, S. D. (2017): Kodak's Downfall Wasn't About Technology. Retrieved from https://hbr.org/2016/07/kodaks-downfall-wasnt-about-technology (04.12.2018)

Arbuckle, G. J. (2016): Iowa Farm and Rural Life Poll: 2016 Summary Report. Retrieved from https://store.extension.iastate.edu/product/Iowa-Farm-and-Rural-Life-Poll-2016-Summary-Report (04.12.2018)

Arun, R., Suresh, V., Madhavan, C. E., Murthy, M. N. (2010): On Finding the Natural Number of Topics with Latent Dirichlet Allocation: Some Observations. Advances in Knowledge Discovery and Data Mining Lecture Notes in Computer Science, pp. 391-402.

Aubert, B. A., Schroeder, A., Grimaudo, J. (2012): IT as enabler of sustainable farming: An empirical analysis of farmers adoption decision of precision agriculture technology. Decision Support Systems, 54(1), pp. 510-520.

Bachhav, N. B. (2012): Information Needs of the Rural Farmers : A Study from Maharashtra, India: A Survey. Library Philosophy and Practice (e-journal). 866, pp. 1-12. Retrieved from https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=2043&context=libphilprac (04.12.2018)

Baron, R. A. (2006): Opportunity Recognition as Pattern Recognition: How Entrepreneurs “Connect the Dots” to Identify New Business Opportunities. Academy of Management Perspectives, 20(1), pp. 104-119.

Basberg, B. L. (1987): Patents and the measurement of technological change: A survey of the literature. Output Measurement in Science and Technology, pp. 77-87.

Baum, J. A., Calabrese, T., Silverman, B. S. (2000): Don’t go it alone: Alliance network composition and startups performance in Canadian biotechnology. Strategic Management Journal, 21(3), pp. 267-294.

Beach, L.R., Mitchell, T.R. (1978): A Contingency Model for the Selection of Decision Strategies,” Academy of Management Review 3(3), pp. 439-449.

Beedell, J., Rehman, T. (1999): Explaining farmers conservation behavior: Why do farmers behave the way they do? Journal of Environmental Management, 57(3), pp. 165-176.

Bergvinson, D. (2017): Digital agriculture empowers farmers. Retrieved from https://www.businesstoday.in/magazine/features/digital-agriculture-empowers-farmers/story/242966.html (04.12.2018)

Bitsch, V. (2000): Agricultural Economics and Qualitative Research: Incompatible Paradigms? Forum Qualitative Social Research, 1(1). Retrieved from http://www.qualitative-research.net/index.php/fqs/issue/view/29 (04.12.2018)

Bitsch, V. (2001): Qualitative Research in Agricultural Economics: Paradigm, Purposes,and Evaluation Criteria, No 20718, 2001 Annual meeting, August 5-8, Chicago, IL, American Agricultural Economics Association (New Name 2008: Agricultural and Applied Economics Association.

Blei, D. M. (2012): Probabilistic topic models. Communications of the ACM, 55(4), pp. 77-84.

Borges, J. A., Lansink, A. G. J. M. O., Ribeiro, C. M., Lutke, V. (2014): Understanding farmers’ intention to adopt improved natural grassland using the theory of planned behavior. Livestock Science, 169, pp. 163-174.

Bovensiepen, G., Hombach, R., Raimund, S. (2016): Quo vadis, agricola? Smart Farming: Nachhaltigkeit und Effizienz durch den Einsatz digitaler Technologien. Retrieved from https://www.pwc.de/de/handel-und-konsumguter/assets/smart-farming-studie-2016.pdf (04.12.2018)

Bowen, G. A. (2008): Naturalistic inquiry and the saturation concept: A research note. Qualitative Research, 8(1), pp. 137-152.

Boyce, C., Neale, P. (2006): Conducting In-Depth Interviews: A Guide for Designing and Conducting In-Depth Interviews for Evaluation Input. Retrieved from http://www2.pathfinder.org/site/DocServer/m_e_tool_series_indepth_interviews.pdf (04.12.2018)

Bruijnis, M., Hogeveen, H., Garforth, C., Stassen, E. (2013): Dairy farmers attitudes and intentions towards improving dairy cow foot health. Livestock Science, 155(1), pp.103-113.

Büschken, J., Allenby, G. M. (2016): Sentence-Based Text Analysis for Customer Reviews. Marketing Science, Articles in Advance, 35(6), 1-23.

CABI (2018): CABI trials PEAT's smartphone app Plantix that identifies plant pests in the field. Retrieved from https://www.cabi.org/news-and-media/2018/cabi-trials-peats-smartphone-app-plantix-that-identifies-plant-pests-in-the-field/ (04.12.2018)

Carr, E. C., Worth, A. (2001): The use of the telephone interview for research. NT Research, 6(1), pp. 511-524.

Cavallo, E., Ferrari, E., Bollani, L., Coccia, M. (2014): Attitudes and behaviour of adopters of technological innovations in agricultural tractors: A case study in Italian agricultural system. Agricultural Systems, 130, pp. 44-54.

CB Insights (2018): The Top 20 Reasons Startups Fail. Retrieved from https://www.cbinsights.com/research/startup-failure-reasons-top/ (04.12.2018)

CEMA (2017): Digital Farming: What does it really mean? Retrieved from http://www.cema-agri.org/images/publications/position-papers CEMA_Digital_Farming_-_Agriculture_4.0__13_02_2017_0.pdf (04.12.2018)

Chang, J., Boyd-Graber, J., Chong Wang, S. G., Blei, D. M. (2009): Reading Tea Leaves: How Humans Interpret Topic Models . Neural Information Processing Systems, pp.1-9.

Chang, J. (2015): lda: Collapsed Gibbs Sampling Methods for Topic Models. R package version 1.4.2. https://CRAN.R-project.org/package=lda (04.12.2018)

Chi, T.T., Yamada, R. (2002): Factors affecting farmers ' adoption of technologies in farming system : A case study in OMon district , Can Tho province , Mekong Delta. Omonrice, 10, pp. 94–100.

Chuang, J., Manning, C. D., Heer, J. (2012): Termite: Visualization Techniques for Assessing Textual Topic Models. Proceedings of the International Working Conference on Advanced Visual Interfaces - AVI 12, pp. 1-4.

Clasen, M. (2005): Erfolgsfaktoren digitaler Marktplätze in der Agrar- und Ernährungsindustrie. Wiesbaden: Deutscher Universitätsverlag.

Clasen, M., Mueller, R. (2006): Success Factors of Agribusiness Digital Marketplaces. Electronic Markets, 16(4), 349-360.

Cold-calling. (n.d.) In Cambridge’s online Dictionary. Retrieved from https://dictionary.cambridge.org/de/worterbuch/englisch/cold-calling (04.12.2018)

Daberkow, S. G., McBride, W. D. (2003): Farm and operator characteristics affecting the awareness and adoption of precision agriculture technologies in the US. Precision Agriculture, 4, pp. 163–177.

Davis, F. D. (1989): Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. MIS Quarterly, 13(3), pp. 319-340.

Decrop, A. (1999): Triangulation in qualitative tourism research. Tourism Management, 20(1), pp. 157-161.

Dedieu, B., Darnhofer, I. , Bellon, S., de Greef, K., Casabianca, F., Madureira, L., Milestad, R., Paine, M., Steyaert, P., Stobbelaar D.J., Zasser-Bedoya, S. (2009): Special issue: Innovations in farming systems approaches. Outlook on agriculture Vol 38(2) ,pp 108–110.

Deloitte (2016): From Agriculture to AgTech An industry transformed beyond molecules and chemicals. Retrieved from https://www2.deloitte.com/content/dam/Deloitte/de/Documents/consumer-industrial-products/Deloitte-Tranformation-from-Agriculture-to-AgTech-2016.pdf (04.12.2018)

Denzin, N. K. (2009): The Research Act: A Theoretical Introduction to Sociological Methods. Routledge, United States of America.

DESTATIS (2017): Publikationen im Bereich Landwirtschaftliche Betriebe. Retrieved from https://www.destatis.de/DE/Publikationen/Thematisch/LandForstwirtschaft/Betriebe/Argrarstukturerhebung.html (04.12.2018)

Dias, C. (2016): German Startup PEAT's Plant Disease App Is Empowering Indian Farmers. Retrieved from http://www.networkedindia.com/2016/10/11/german-startup-peats-plant-disease-app-empowering-indian-farmers/ (04.12.2018)

Eastwood, C., Klerkx, L., Nettle, R. (2017): Dynamics and distribution of public and private research and extension roles for technological innovation and diffusion: Case studies of the implementation and adaptation of precision farming technologies. Journal of Rural Studies, 49, pp. 1-12.

EIP-AGRI Focus Group (2015): Precision farming. Final report. Retrieved from https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eip-agri_focus_group_on_precision_farming_final_report_2015.pdf (04.12.2018)

European Commission – EU FADN (2011): Farm Economics brief. EU production costs overview. Retrieved from http://ec.europa.eu/agriculture/rica/pdf/Brief201102.pdf (04.12.2018)

FAO (2009): Global agriculture towards 2050. Retrieved from http://www.fao.org/fileadmin/templates/wsfs/docs/Issues_papers/HLEF2050_Global_Agriculture.pdf (04.12.2018)

FAO (2014): Contribution to the 2014 United Nations Economic and Social Council (ECOSOC) Integration Segment. http://www.un.org/en/ecosoc/integration/pdf/crd.pdf (04.12.2018)

Far, S. T., Rezaei-Moghaddam, K. (2017): Determinants of Iranian agricultural consultants' intentions toward precision agriculture: Integrating innovativeness to the technology acceptance model. Journal of the Saudi Society of Agricultural Sciences, 16(3), pp. 280-286.

Farquharson, R. J., Martin, R. J., Mccorkell, B., Scott, J. F., Sotheary, E., Phaloeun, C., Sophors, H., Monida, C., Sinarong, S., Sokun, B. (2013): Characteristics of an Agricultural Innovation and Incentives for Adoption: Rhizobium in Cambodia. International Journal of Environmental and Rural Development, 4(2), pp. 44-49.

Fecke, W., Danne, M., Mußhoff, O. (2018): E-commerce in agriculture – The case of crop protection product purchases in a discrete choice experiment. Computers and Electronics in Agriculture, 151, pp. 126-135.

Feder, G., Umali, D. L. (1993): The adoption of agricultural innovations: A review. Technological Forecasting and Social Change, 43(3-4), 215-239.

Feinerer I., Hornik K. (2018): tm: Text Mining Package. R package version 0.7-5. https://CRAN.R-project.org/package=tm (04.12.2018)

Fishbein, M., Ajzen, I. (1975): Belief, attitude, intention, and behavior: An introduction to theory and research. Reading, MA: Addison-Wesley.

Flick, U. (2004): Triangulation in qualitative research. In Flick, U., von Kardorff, E, Steinke, I. (Eds.), A Companion to Qualitative Research. London: SAGE Publications, pp. 178–183.

Floy, S. (2017): Agriculture Marketplaces: Building a platform for farmer produce in Tanzania with Maria Biswalo from Ninayo. Retrieved from http://www.samfloy.com/podcast/agriculture-marketplaces-building-a-platform-for-farmer-produce-in-tanzania-with-maria-biswalo-from-ninayo/ (04.12.2018)

Foster, R. N. (1986): Working The S-Curve: Assessing Technological Threats. Research Management, 29(4), pp. 17-20.

Fountas, S., Pedersen, S.M., Blackmore, S. (2005): ICT in Precision Agriculture – diffusion of technology. In "ICT in Agriculture: Perspectives of Technological Innovation " edited by E. Gelb, A. Offer, pp 1-15.

Friese, S. (2014): Qualitative data analysis with ATLAS.ti (2nd ed.) London: Sage Publications.

Gagolewski M., Tartanus, B. (2018): R package stringi: Character string processing facilities. http://www.gagolewski.com/software/stringi/ (04.12.2018)

GIZ (2018): Nachhaltige Landwirtschaft und ländliche Entwicklung. Retrieved from https://www.giz.de/de/weltweit/22735.html (04.12.2018)

Gladwell, M. (2001): The Tipping Point: How Little Things Can Make a Big Difference (1st ed.). Little, Brown and Company, USA.

Glanz, K., Rimer, B. K., Viswanath, K. (2008): Health behavior and health education: Theory, research, and practice. San Francisco, CA: Jossey-Bass.

Goedde, L., Fischer, J., Denis, N., Tanaka, M., Yamada, Y. (2016): Empowering Japanese agriculture for global impact. Retrieved from https://www.mckinsey.com/~/media/McKinsey/Featured Insights/Asia Pacific/Strengthening Japanese agriculture to maximize global reach/Empowering-japanese-agriculture-FULL-REPORT.ashx (04.12.2018)

Goedde, L., Horii, M., Sanghvi, S. (2015): Global agriculture's many opportunities. Retrieved from https://www.mckinsey.com/~/media/McKinsey/Industries/Private Equity and Principal Investors/Our Insights/Global agricultures many opportunities/Global agricultures many opportunities.ashx (04.12.2018)

Granovetter, M. (1978): Threshold Models of Collective Behavior. American Journal of Sociology, 83(6), pp. 1420-1443.

Grinin, L., Korotayev, A., Tausch, A. (2018): Economic cycles, Crises, and the Global Periphery. S.L: Springer, pp.23-54.

Gruner, K. E., Homburg, C. (2000): Does Customer Interaction Enhance New Product Success? Journal of Business Research, 49(1), pp. 1-14.

Guest, G., Bunce, A., Johnson, L. (2006): How Many Interviews Are Enough? An Experiment with Data Saturation and Variability. Field Methods, 18(1), pp. 59-82.

Hancock, D. R., Algozzine, R. (2017): Doing case study research: A practical guide for beginning researchers. New York, NY: Teachers College Press.

Hattam, C. (2006): Barriers to the adoption of organic agriculture An investigation using the Theory of Planned Behavior. In: Atkinson, C; Ball, B; Davies, D H K; Rees, R; Russell, G; Stockdale, E A; Watson, C A; Walker, R and Younie, D (Eds.) Aspects of Applied Biology 79, What will organic farming deliver? COR 2006, Association of Applied Biologists, p. 73.

Haupt, R., Kloyer, M., Lange, M. (2007): Patent indicators for the technology life cycle development. Research Policy, 36(3), pp.387-398.

Holstein, J.A., Gubrium, J.F. (1997): Active interviewing. In D. Silverman (ed.) Qualitative Research: Theory, Method and Practice, London: Sage, pp. 140-161

Hornik, K. (2017): NLP: Natural Language Processing Infrastructure. R package version 0.1-11. https://CRAN.R-project.org/package=NLP (04.12.2018)

Hoyer, W. D., Chandy, R., Dorotic, M., Krafft, M., Singh, S. S. (2010): Consumer Cocreation in New Product Development. Journal of Service Research, 13(3), pp. 283-296.
Hwang, S. (2008): Utilizing Qualitative Data Analysis Software: A Review of Atlas.ti. Social Science Computer Review, 26(4), pp. 519–527.

ICRISAT (2017): Mobile App to Help Farmers Overcome Crop Damage. Retrieved from https://www.icrisat.org/mobile-app-to-help-farmers-overcome-crop-damage/ (04.12.2018)

Indian Ministry of Agriculture and Farmers Welfare (2018): National Conference. Agriculture 2022 Doubling Farmer’s Income. Retrieved from http://oar.icrisat.org/10438/1Science%20%26%20Technology%20and%20Startups%20in%20Agriculture.pdf (04.12.2018)

Jackiewicz, Z. (2017): U.S. Data-Driven Farming Prize Awards $300,000 for Innovative Agricultural Solutions in Nepal. Retrieved from https://datadrivenfarming.challenges.org/2017/09/08/u-s-data-driven-farming-prize-awards-300000-innovative-agricultural-solutions-nepal/ (04.12.2018)

Jarolímek, J., Stočes, M., Masner, J., Vaněk, J., Šimek, P., Pavlík, J., Rajtr, J. (2017): User-Technological Index of Precision Agriculture. Agris On-line Papers in Economics and Informatics, 09(01), pp. 69-75.

Järvenpää, H. M., Mäkinen, S. J., Seppänen, M. (2011): Patent and publishing activity sequence over a technologys life cycle. Technological Forecasting and Social Change, 78(2), pp. 283-293.

Jarvis, D., Wachowiak, M., Walters, D., Kovacs, J. (2017): Adoption of Web-Based Spatial Tools by Agricultural Producers: Conversations with Seven Northeastern Ontario Farmers Using the GeoVisage Decision Support System. Agriculture, 7(8), 69, pp. 2-22.

Kahenya, D. W., Sakwa, M., Iravo, M. (2014): Assessing Use of Information Communication Technologies among Agricultural Extension Workers in Kenya Using Modified UTAUT Model. International Journal of Sciences: Basic and Applied Research, 16, 11-22.

Kaloxylos, A., Eigenmann, R., Teye, F., Politopoulou, Z., Wolfert, S., Shrank, C., Dillinger, M., Lampropoulou, I., Antoniou, E., Pesonen, L., Nicole, H., Thomas, F., Alonistioti, N.,Kormentzas, G. (2012): Farm management systems and the Future Internet era. Computers and Electronics in Agriculture, Computers and Electronics in Agriculture 89, pp. 130-144.

Kashyap, K. (2017): Startups Are Leading To Vital Changes In India's Farm Sector. Retrieved from https://www.forbes.com/sites/krnkashyap/2017/09/18/startups-are-leading-to-vital-changes-in-indias-farm-sector/#3a04bd9c1e7c (04.12.2018)

Kaulio, M. A. (1998): Customer, consumer and user involvement in product development: A framework and a review of selected methods. Total Quality Management, 9(1), pp.141-149.

Kleffmann Group (2016): New Media Tracker 2016. Retrieved from https://www.kleffmann.com/en/information-center/information-center/new-media-tracker/ (04.12.2018)

Kollmann, T., Stöckmann, C., Hensellek, S., Kensbock, J. (2016): European startup monitor. Retrieved from http://europeanstartupmonitor.com/fileadmin/esm_2016/report/ESM_2016.pdf (04.12.2018)

Lagrosen, S. (2005): Customer involvement in new product development. European Journal of Innovation Management, 8(4), pp. 424-436.

Läpple, D., Kelly, H. (2010): Understanding farmers' uptake of organic farming. An application of the theory of planned behaviour. Agricultural Economics Society 84th Annual Conference, March 29-31, 2010 (pp. 1-29). Edinburgh, Scotland. Retrieved from https://ageconsearch.umn.edu/record/91949?ln=en (04.12.2018)

Lauwere, C. D., Asseldonk, M. V., Riet, J. V., Hoop, J. D., Pierick, E. T. (2012): Understanding farmers decisions with regard to animal welfare: The case of changing to group housing for pregnant sows. Livestock Science, 143(2-3), pp. 151-161.

Lee, A. S., Baskerville, R. L. (2003): Generalizing Generalizability in Information Systems Research. Information Systems Research, 14(3), pp. 221-243.

Legard, R., Keegan, J., Ward, K. (2003): In-depth Interviews. In: Ritchie, J. and Lewis, J., Eds., Qualitative Research Practice, A guide for Social Science Students and Researcher. Sage, London, pp. 139-168.

Leitgeb, F., Funes-Monzote, F.R., Kummer, S, Vogl, C. R. (2011): Contribution of farmers' experiments and innovations to Cuba's agricultural innovation system. Renewable Agriculture and Food Systems, 26(4), pp. 354–367.

Lele, U. (2017): How technology is helping India's rural poor. Retrieved from https://www.weforum.org/agenda/2017/10/india-fourth-industrial-revolution-farming/ (04.12.2018)

Lencsés, E., Takács, I., Takács-György, K. (2014): Farmers' Perception of Precision Farming Technology among Hungarian Farmers. Sustainability, 6(12), pp. 8452-8465.

Lima, E., Hopkins, T., Gurney, E., Shortall, O., Lovatt, F., Davies, P., Williamson, G., Kaler, J. (2018): Drivers for precision livestock technology adoption: A study of factors associated with adoption of electronic identification technology by commercial sheep farmers in England and Wales. Plos One, 13(1), pp. 1-17.

Linden, A., Fenn, J. (2003): Understanding Gartner's Hype Cycles. Retrieved from https://www.bus.umich.edu/KresgePublic/Journals/Gartner/research/115200/115274/115274.pdf (04.12.2018)

Mahajan, V., Muller, E., Bass, F. M. (1990): New Product Diffusion Models in Marketing: A Review and Directions for Research. Journal of Marketing, 54(1), pp. 1-26.

Mahamood, A. F., Mohammed, R., Ahmad, M. K., Ridzuan, A. H., Hamzah, M. R., Abdullah, S., Shaffril, H. A. (2016): Applying Diffusion of Innovation Theory and Unified Theory of Acceptance and Use of Technology (UTAUT) on Farmers' Use of Communication Technology. Journal of Human Development and Communication, 5. pp. 27-40.

Mankins, J. (1995): Technology Readiness Levels—A White Paper. Washington, DC, USA: Advanced Concepts Office, Office of Space Access and Technology, National Aeronautics and Space Administration (NASA). https://www.researchgate.net/publication/247705707_Technology_Readiness_Level_-_A_White_Paper (04.12.2018)

Marmer, M., Hermann, B. L., Dogrultan, E., Berman, R. (2011): Startup Genome Report. Extra on Premature Scaling. A deep dive into why most high growth startups fail. Retrieved from http://innovationfootprints.com/wp-content/uploads/2015/07/startup-genome-report-extra-on-premature-scaling.pdf (04.12.2018)

Martins, E., Terblanche, F. (2003): Building organisational culture that stimulates creativity and innovation. European Journal of Innovation Management, 6(1), pp. 64-74.

Meijer, S. S., Catacutan, D., Sileshi, G. W., Nieuwenhuis, M. (2015): Tree planting by smallholder farmers in Malawi: Using the theory of planned behavior to examine the relationship between attitudes and behavior. Journal of Environmental Psychology, 43, pp. 1-12.

Mel (2015): GartenBank-App hilft bei Schädlingen und Pflanzenkrankheiten. Retrieved from https://www.kistengruen.de/wp/2015/08/gartenbank/ (04.12.2018)

Merriam, S. B. (2001): Qualitative research and case study applications in education. San Francisco: Jossey-Bass

Mgbakor, M., Iyobor, O., Okezie, U. P. (2013): Contributions of Mass Media to the Development of Agricultural Extension in Ika North East L.G.A of Delta State, Nigeria. Academic Journal of Plant Sciences, 6(3), pp. 127-133.

Michailidis, A., Marantidou, A., Koutsouris, A., Papadaki-Klavdianou, A., Samathrakis, V. (2008): Adoption of Information and Communication Technologies among Farmers in the Region of West Macedonia. Proceedings of the International Advanced Workshop on Information and Communication Technologies for Sustainable Agri-production and Environment, pp. 339-349.

Miles, M.B., Huberman, A.M. (1984): Qualitative Data Analysis: A Sourcebook of New Methods, Sage, Beverly Hills, CA.

Miller, C. (2017): Nuffield research tracks potential livestock gains. Retrieved from https://www.stockjournal.com.au/story/4597857/nuffield-research-tracks-potential-livestock-gains/ (04.12.2018)

Mingay, G.E. (1963): The "Agricultural Revolution" in English History: A Reconsideration. Agricultural History, 37(3),pp. 123-133.

Ministry of Agriculture and Farmers Welfare (2018): National Conference Agriculture 2022 Doubling Farmers' Income. Retrieved from http://oar.icrisat.org10438/1Science%20%26%20Technology%20and%20Startups%20in%20Agriculture.pdf (04.12.2018)

Mittal, S., Mehar, M. (2015): Socio-economic Factors Affecting Adoption of Modern Information and Communication Technology by Farmers in India: Analysis Using Multivariate Probit Model. The Journal of Agricultural Education and Extension, 22(2), pp. 199-212.

Moore, G. A. (1999): Crossing the chasm marketing and selling disruptive products to mainstream customers (2nd ed.). New York, NY: Harper Business.

Ritchie, J., Lewis, J. (2003): Qualitative research practice: A guide for social science students and researchers. London: SAGE.

Mwakaje, A. G. (2010): Information and Communication Technology for Rural Farmers Market Access in Tanzania. Journal of Information Technology Impact, 10(2), pp. 111-128.

National Economic Council (2011): The Small Business Agenda. Retrieved from https://www.sba.gov/document/report--small-business-agenda (04.12.2018)

O'Leary, Z. (2004): The essential guide to doing research. London: SAGE, pp.4-8.

OECD (2018): Global Forum on Agriculture. How digital technologies are impacting the way we grow and distribute food. Digital technologies in food and agriculture: Reaping the benefits. Retrieved from https://www.oecd.org/tad/events/Background note_Website.pdf (04.12.2018)

Opdenakker, R. (2006): Advantages and disadvantages of four interview techniques in qualitative research. Forum Qualitative Sozialforschung / Forum: Qualitative Social Research, 7(4), Art. 11, Retrieved from http://nbn-resolving.de/urn:nbn:de:0114-fqs0604118 (04.12.2018)

Owens, T., Fernandez, O. (2014): The lean enterprise: How corporations can innovate like startups. Hoboken, NJ: Wiley.

Paustian, M., Theuvsen, L. (2016): Adoption of precision agriculture technologies by German crop farmers. Precision Agriculture pp. 1-16.

Peshin, R. (2013): Farmers' adoptability of integrated pest management of cotton revealed by a new methodology. Agronomy for Sustainable Development, 33(3), pp. 563-572.

Pierpaoli, E., Carli, G., Pignatti, E., Canavari, M. (2013): Drivers of Precision Agriculture Technologies Adoption: A Literature Review. Procedia Technology, 8, pp. 61-69.

Pignatti, E., Carli, G., Canavari, M. (2015): What really matters? A qualitative analysis on the adoption of innovations in agriculture. Journal of Agricultural Informatics, 6(4), pp. 73-84 .

Plantix App. (n.d.): Plantix – Apps bei Google Play. Retrieved from https://play.google.com/store/apps/details?id=com.peat.GartenBank&hl=de (04.12.2018)

Produkt+Markt Marketing Research (2013): agriMA Insights zur aktuellen Mediennutzung in der Landwirtschaft -. Retrieved from https://docplayer.org/22096615-Ma-2013-insights-zur-aktuellen-mediennutzung-in-der-landwirtschaft.html (04.12.2018)

Ram, S., Sheth, J. N. (1989): Consumer Resistance to Innovations: The Marketing Problem and its solutions. Journal of Consumer Marketing, 6(2), pp. 5-14.

Reichardt, M., Jürgens, C., Klöble, U., Hüter, J., Moser, K. (2009): Dissemination of precision farming in Germany: Acceptance, adoption, obstacles, knowledge transfer and training activities. Precision Agriculture, 10(6), pp. 525-545.

Rezaei-Moghaddam, K., Salehi, S. (2010): Agricultural specialists' intention toward precision agriculture technologies: Integrating innovation characteristics to technology acceptance model. African Journal of Agricultural Research, 5(11), pp. 1191-1199.

Ries, E. (2011): The lean startup: How constant innovation to creates radically successful businesses. London: Portofolio.

Roberts, D. (2018): This company wants to build a giant indoor farm next to every major city in the world. Retrieved from https://www.vox.com/energy-and-environment/2017/11/8/16611710/vertical-farms (04.12.2018)

Rogers, E. M. (1983): Diffusion of innovation (3rd ed.). New York: Free Press.

Rohleder, B., Krüsken, B. (2016): Digitalisierung in der Landwirtschaft. Retrieved from https://www.bitkom.org/sites/default/files/pdf/Presse/Anhaenge-an-PIs/2016/November/Bitkom-Pressekonferenz-Digitalisierung-in-der-Landwirtschaft-02-11-2016-Praesentation.pdf (04.12.2018)

Salami, P., Ahmadi, H. (2010): Review of Farm Management Information Systems (FMIS). New York Science Journal, 3(5), pp. 87-95.

Saldaña, J. (2016): The Coding manual for qualitative researchers. Los Angeles: SAGE.

Sattar, R.A. , Wang, S., Muqadas, M., Ashraf, M.F., Tahir M.N. (2017): Qualitative and quantitative approaches to study adoption of sustainable agricultural practices: a research-note on mixed method approach. International Journal of Agricultural Extension and Rural Development, 5 (2), pp. 539–44.

Schendel, D., Hofer, C.W. (1979): Strategic management: A new view of business policy and planning. Boston: Little Brown & Company.

Schrijver, R., Poppe, K., Daheim, C. (2016): Precision agriculture and the future of farming in Europe. Retrieved from http://www.europarl.europa.eu/RegData/etudes/STUD/2016/581892/EPRS_STU(2016)581892_EN.pdf (04.12.2018)

Schumpeter, J.A. (1947): Capitalism, socialism and democracy. London: Allen & Unwin.

Seja, C. (2013): Empfehlungserfolge durch Involvement-Marketing. Berlin: Uni-Edition.

Seth, A., Ganguly, K. (2017): Digital Technologies Transforming Indian Agriculture. In Dutta, S., Lanvin, B., Wunsch-Vincent, S. (Editors): The Global Innovation Index 2017 Innovation Feeding the World (10th edition).Cornell University, INSEAD, and the World Intellectual Property Organization, 2017, pp.105-111. Retrieved from https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2017-chapter5.pdf (04.12.2018)

Shankar, S., Vignesh, J. (2016): How the startup boom is helping farmers and forcing investors to pay attention to agriculture. Retrieved from https://economictimes.indiatimes.com/small-biz/startups/how-the-startup-boom-is-helping-farmers-and-forcing-investors-to-pay-attention-to-agriculture/articleshow/52893242.cms (04.12.2018)

Shen, S., Basist, A., Howard, A. (2010): Structure of a digital agriculture system and agricultural risks due to climate changes. Agriculture and Agricultural Science Procedia, 1, pp. 42-51.

Sievert, C., Shirley, K. (2014): LDAvis: A method for visualizing and interpreting topics. Proceedings of the Workshop on Interactive Language Learning, Visualization, and Interfaces, pp. 63-70.

Sievert C., Shirley K. (2015): LDAvis: Interactive Visualization of Topic Models. R package version 0.3.2.https://CRAN.R-project.org/package=LDAvis (04.12.2018)

Smith, K. G., Carroll, S. J., Ashford, S. J. (1995): Intra- and Interorganizational Cooperation: Toward a Research Agenda. Academy of Management Journal, 38(1), pp. 7-23.

Sommerlatte, T., Deschamps, J.-P. (1986): Der strategische Einsatz von Technologien. In Management im Zeitalter der strategischen Führung. Wiesbaden: Gabler, pp. 39–76.

Sørensen, C., Fountas, S., Nash, E., Pesonen, L., Bochtis, D., Pedersen, S., Marcus, S., Basso, B., Blackmore, S. (2010): Conceptual model of a future farm management information system. Computers and Electronics in Agriculture, 72(1), pp.37-47.

Stake, R. (1995): The art of case study research. Thousand Oaks, CA: Sage.

Start-Green (2018): PEAT. Retrieved from https://start-green.net/netzwerk/gruenes-startup/peat/ (04.12.2018)

Startup India (2018): What qualifies as a "Startup" for the purpose of Startup India? Retrieved from https://www.startupindia.gov.in/content/sih/en/faqs.html (04.12.2018)

Statista (2018): Global precision farming by segment: Addressable market 2050, Statistic. Retrieved from https://www.statista.com/statistics/709440/estimated-size-of-the-global-precision-farming-market-by-technology/ (04.12.2018)

Statista (2018): Startups operating in agriculture by sector in Italy 2017, Statistic. Retrieved from https://www.statista.com/statistics/874944/startups-operating-in-agriculture-by-sector-in-italy/ (04.12.2018)

Statista (2018): Worldwide IoT in agriculture market by application 2016, Statistic. Retrieved from https://www.statista.com/statistics/766791/global-iot-in-agriculture-market-by-application/ (04.12.2018)

Steeneveld, W., Hogeveen, H., Oude Lansink, A.G.J.M. (2015): Economic consequences of investing in sensor systems on dairy farms. Computers and Electronics in Agriculture, 119, pp. 33-39.

Stokes, D., Bergin, R. (2006): Methodology or “methodolatry”? An evaluation of focus groups and depth interviews. Qualitative Market Research: An International Journal, 9 (1), pp. 26-37.

Strauss, A.L., Corbin, J.M. (1998): Basics of qualitative research techniques and procedures for developing grounded theory. Thousand Oaks: Sage Publ.

Stricker S., Emmel, M., Pape, J. (2003): Situation of Agricultural Information and Communication Technology (ICT) in Germany. In: Harnos, Z., Herdon, M. und T.B. Wiwczaroski: Information technology for a better agri-food sector, environment and rural living, pp. 690-698.

Sullivan, L.P. (1986): Quality function deployment. Quality Progress, June, pp. 39-50

Taherdoost, H. (2018): A review of technology acceptance and adoption models and theories. Procedia Manufacturing, 22, pp.960-967.

TechAmerica Foundation's Federal Big Data Commission (n.d.): Demystifying Big Data. A practical Guide to Transforming the Business of Government." https://statswiki.unece.org/pages/viewpage.action?pageId=80053387 (04.12.2018)

Technofarm (2018): Connecting Leaves to Lives. Retrieved from http://technofarm.com/en/ (04.12.2018)

The Economic Times (2018): Government to expand DigiGaon project to 700 villages this year. Retrieved from https://economictimes.indiatimes.com/news/politics-and-nation/government-to-expand-digigaon-project-to-700-villages-this-year/articleshow/64245998.cms (04.12.2018)

Urban, G., von Hippel, E. (1988): Lead user analysis for the development of new industrial products. Management Science, 34, pp. 569-582.

USAID (2017): Nepal Seed and Fertilizer Project Annual. Report Year 1 April 1, 2016- September 30, 2017. Retrieved from https://repository.cimmyt.org/xmlui/bitstream/handle/10883/19291/59266.pdf?sequence=1&isAllowed=y (04.12.2018)

van Es, H., Woodard, J. (2017): Innovation in Agriculture and Food Systems in the Digital Age. In Dutta, S., Lanvin, B., Wunsch-Vincent, S. (Editors): The Global Innovation Index 2017 Innovation Feeding the World (10th edition).Cornell University, INSEAD, and the World Intellectual Property Organization, 2017, pp. 97-104. Retrieved from https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2017-chapter4.pdf (04.12.2018)

Vasterman, P.L. (2005): Media-Hype. Self-Reinforcing News Waves, Journalistic Standards and the Construction of Social Problems. European Journal of Communication, 20(4), pp. 508-530.

Venkatesh, V., Davis, F. D. (1996): A Model of the Antecedents of Perceived Ease of Use: Development and Test. Decision Sciences, 27(3), pp. 451-481.

Venkatesh, V., Davis, F. D. (2000): A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. Management Science, 46(2), pp. 186-204.

Venkatesh, V., Morris, M.G., Davis, G.B., Davis, F.D. (2003): User Acceptance of Information Technology: Toward a Unified View. MIS Quarterly, 27(3), pp. 425-478.

Vincent, J. (2018): The robotic farm of the future isn't what you'd expect. Retrieved from https://www.theverge.com/2018/10/9/17950502/robot-farm-future-iron-ox-agriculture-automation (04.12.2018)

Viva (2017): Tanihub, Bisnis E-Commerce Petani Beromzet Rp1 Miliar – VIVA. Retrieved from https://www.viva.co.id/berita/bisnis/873598-tanihub-bisnis-e-commerce-petani-beromzet-rp1-miliar (04.12.2018)

von Hippel, E. V. (1976): The dominant role of users in the scientific instrument innovation process. Research Policy, 5(3), pp. 212-239.

von Jeinsen, T.A., Heppe, H., Theuvsen, L. (2018): Determinanten der Akzeptanz technischer Innovationen in der Landwirtschaft.In A.Ruckelshausen et al.Digitale Marktplätze und Plattformen, Lecture Notes in Informatics (LNI), Gesellschaft für Informatik, Bonn, pp. 127-130.

Warren, M.F. (2004): Farmers online: Drivers and impediments in adoption of Internet in UK agricultural businesses. Journal of Small Business and Enterprise Development, 11(3), pp. 371-381.

Watts, R.J., Porter, A.L. (1997): Innovation forecasting. Technological Forecasting and Social Change, 56(1), pp. 25-47.

Wauters, E., Bielders, C., Poesen, J., Govers, G., Mathijs, E. (2010): Adoption of soil conservation practices in Belgium: An examination of the theory of planned behaviour in the agri-environmental domain. Land Use Policy, 27(1), pp. 86-94.

Wickham, H., François, R., Henry, L., Müller, K. (2018): dplyr: A Grammar of Data Manipulation. R package version 0.7.6. https://CRAN.R-project.org/package=dplyr (04.12.2018)

Wikipedia (2018): Simone Strey. Retrieved from https://en.wikipedia.org/wiki/Simone_Strey (04.12.2018)

Wolfert, S., Ge, L., Verdouw, C., Bogaardt, M. (2017): Big Data in Smart Farming – A review. Agricultural Systems, 153, pp. 69-80.

WSA (2016): Plantix. Retrieved from https://www.worldsummitawards.org/winner/plantix/ (04.12.2018)

Yaseen, M., Xu, S., Yu, W., Hassan, S. (2016): Farmers' Access to Agricultural Information Sources: Evidences from Rural Pakistan. Journal of Agricultural Chemistry and Environment, 05(01), pp.12-19.

Yazan, B. (2015): Three Approaches to Case Study Methods in Education: Yin, Merriam, and Stake. The Qualitative Report, 20(2), pp. 134-152.

Yazdanpanah, M., Hayati, D., Hochrainer-Stigler, S., Zamani, G. H. (2014): Understanding farmers intention and behavior regarding water conservation in the Middle-East and North Africa: A case study in Iran. Journal of Environmental Management, 135, pp. 63-72.

Yin, R.K. (1982): Case study research: Design and methods (2nd ed.). Thousand Oaks, CA: SAGE Publications.

Yin, R.K. (2002): Case study research: Design and methods (3d ed.). Thousand Oaks, CA: SAGE Publications.

Zhang, B., Peng, B., Qiu, J.(2015): Parallel LDA Through Synchronized Communica- tion Optimizations. Technical Report Retrieved from http://dsc.soic.indiana.edu/publications/LDA optimization paper.pdf (04.12.2018)

Zubair, M., Garforth, C. (2006): Farm Level Tree Planting in Pakistan: The Role of Farmers' Perceptions and Attitudes. Agroforestry Systems, 66(3), pp. 217-229.

9 Annex

9.1 Semi-structured questionnaire for the in-depth interviews

Questions about founder:

1. How many founders are there in your startup?
2. What kind of background do you have?

Questions about the startup

1. Can you please tell me a bit more about you startup? How did it all start?
2. How long have you been developing the idea?
3. What kind of growth are you expecting during the coming year?
4. How do you measure your growth?
5. Do you have any growth milestones?

Questions about the product/service

1. What are the main functions of your solution?
2. What makes your solution unique?
3. How well does your solution work? What kind of feedback did your customers provide?
4. Is there something your customers especially like in your solution?
5. How much does your solution cost?

Questions about the marketing strategies

1. Could you describe who the early adopters of your solution are?
2. How many users had already tested your solution before it appeared on the market?
3. How did you develop the solution? Were the early adopters involved, if yes then how?
4. How did you find the early adopters?
5. What channels did you use to reach the potential customers?
6. How did you find out what channel works the best for customer acquisition?
7. How do you usually communicate with your customers?
8. From your perspective, what kind of partners are important for growth on the market?

9.2 First round of codes from the in-depth interviews

9.3 Structured questionnaire for the telephone interview with FMIS startups and online marketplaces

1. Wie alt ist der Geschätsführer / sind die Geschftsführer?

2. Hat jemand aus eurer Geschäftsführung bereits ein anderes Startup / Unternehmen gegründet? Ja/ Nein

3. Wie viele Mitarbeiter (außer Gründer) gibt es in deinem Unternehmen?

4. Bietet ihr eine kostenlose Probeversion eures Produkts an?Ja / Nein

5. Kannst du deinen Kunden einen positiven Einfluss deines/eueres Produktes aufzeigen? Ja/ Nein
Wenn ja, wie?

6. Auf welche Unternehmen ist euer Produkt ausgerichtet?
a) Großunternehmen
b) Mittlere und kleine Unternehmen

7. Habt ihr strategische Partnerschaften?
Wenn ja, zu welchem Zweck?
a) Ausbildung der Landwirte
b) Distribution
c) Werbung
d) andere (welche?)

8. Hat euer Produkt Schnittstellen mit anderen existierenden Farm Management Systemen / online Marktplätzen?

9. Wurde euer Produkt in einer Kooperation mit Landwirten entwickelt?

10. Wie viele Kunden habt ihr in Deutschland?

9.4 R code that was used to analyze qualitative data for the case study

```
#source: https://ldavis.cpsievert.me/reviews/reviews.html

# libraries

library(NLP)
library(dplyr)
library(stringi)
library(tm)

# setting stop words

# English stop words
stop_words <- stopwords(“SMART")

# German stop words
myStopwords <-
c("fuer","ueber","waehrend","dass","keonnen","koennte","koennten","wuerde","die"
,"der","das","den","dem","des","nur","und","ein","eine","einer","einen","noch","scho
n","aber","dabei","zu","waere","doch","jedoch","zwar","app","natuerlich","unserer","
deren","mithilfe","ab","wurde","bereits","gibt","up","dafuer","a","oft","mehr","sagt","
moeglich","hinaus","zudem","acht","simone","immer","zahn","beispiel","wer","unser
e","per","genau","munzel","gmbh","sei","daher","dahinter","laut","ag","geben","gera
de","mittlerweile","geht","start","strey","pierre","steht","koennen","ziemlich","bzw","s
ebastian","stehen","aktuell","insgesamt","eigenen","ebenfalls","dadurch","darueber
","sowie","eins","ja","kurz","vielen","hast","mittels","demnaechst","etwa","viele","ups
","umso","denen","besonders","sollen","energieheld","wirklich","hartberger","mal","t
eil","in","im","zum","je","mit")


# import data for analysis

Dataset <-
read.table("./data_raw/app_in_eng.csv",
header=FALSE, sep=";", na.strings="NA", dec=".", strip.white=TRUE)

names(Dataset)[c(1,2,3)] <- c("year","comment","rating")


# pre-processing the data

# make tibble from dataset
data_set <- as_tibble(Dataset)


# generate string length column

data_set2 <- mutate(data_set, comment_len = stri_length(comment))
```

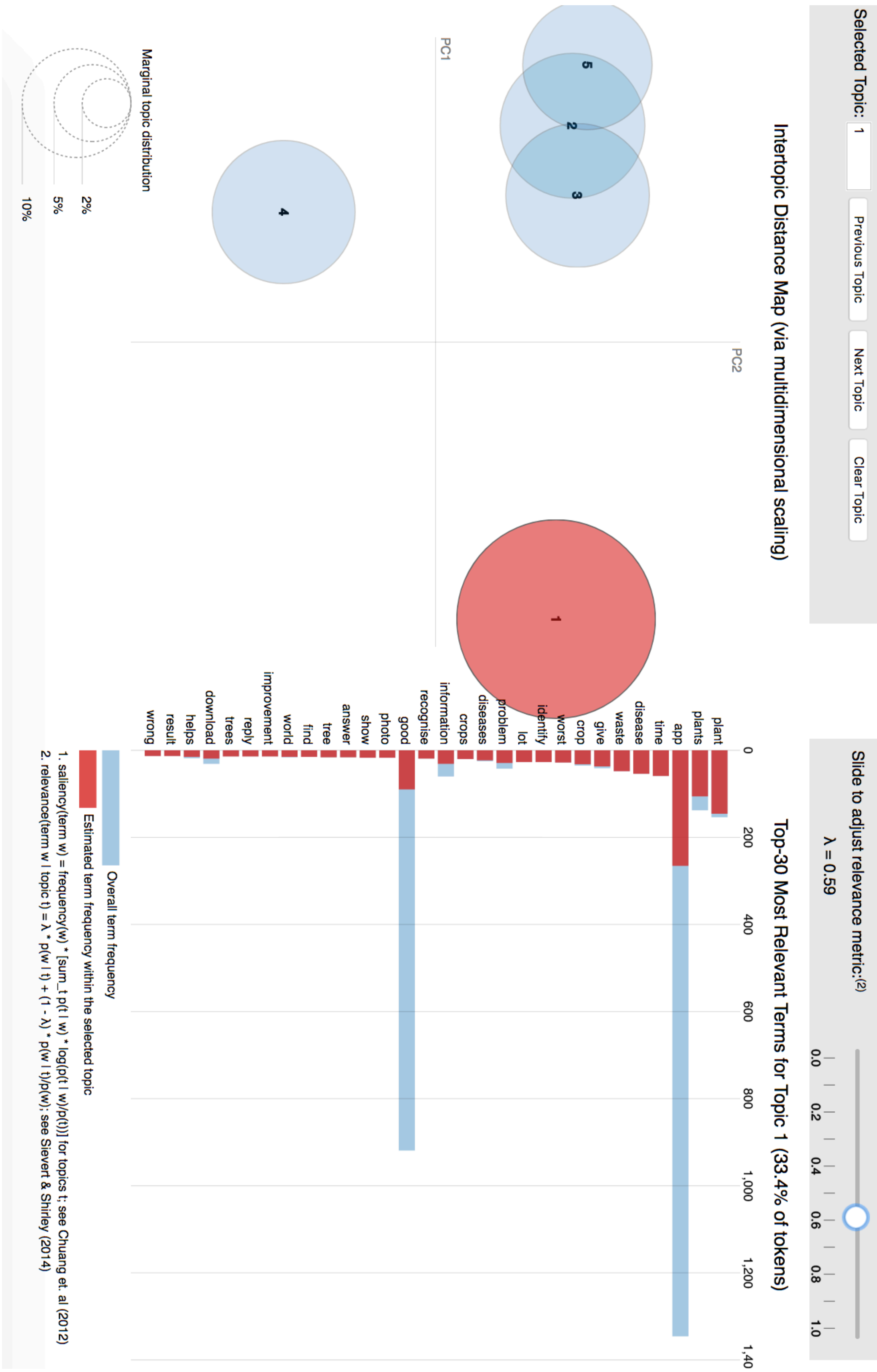
```
# delete NaNs
data_set2 <- na.omit(data_set2)

# convert comments from factor to character

data_set2 %>% mutate_if(is.factor, as.character) -> data_set2

# clean comments
reviews <- as.data.frame(data_set2)

reviews[,2] <- gsub("'", "", reviews[,2])  # remove apostrophes
reviews[,2] <- gsub("[[:punct:]]", " ", reviews[,2])  # replace punctuation with space
reviews[,2] <- gsub("[[:cntrl:]]", " ", reviews[,2])  # replace control characters with
space
reviews[,2] <- gsub("^[[:space:]]+", "", reviews[,2]) # remove whitespace at
beginning of documents
reviews[,2] <- gsub("[[:space:]]+$", "", reviews[,2]) # remove whitespace at end of
documents
reviews[,2] <- tolower(reviews[,2])  # force to lowercase
reviews_cleaned <- as.data.frame(reviews)


#filtering positive review (the same procedure for negative review)

reviews_cleaned_positive <- filter(reviews_cleaned, rating == 5 | rating == 4)

reviews_cleaned_negative <- filter(reviews_cleaned, rating == 2 | rating == 1)

#get average length of the positive reviews
positive_comment_len <- reviews_cleaned_positive$comment_len

# show histogram
hist(positive_comment_len)

# calculate mean and median
mean(positive_comment_len)
median(positive_comment_len)
summary(positive_comment_len)

#average length of the negative reviews

negative_comment_len <- reviews_cleaned_negative$comment_len

# calculate mean and median
mean(negative_comment_len)
median(negative_comment_len)
summary(negative_comment_len)

# mode
pos_y <- table(positive_comment_len)
```

```
names(pos_y)[which(pos_y==max(pos_y))]
sort(pos_y)
summary(pos_y)
reviews_cleaned <- reviews_cleaned_negative


# tokenize on space and output as a list

doc.list <- strsplit(reviews_cleaned[,2], "[[:space:]]+")

# compute the table of terms
term.table <- table(unlist(doc.list))
term.table <- sort(term.table, decreasing = TRUE)

# remove terms that are stop words or occur fewer than 5 times
del <- names(term.table) %in% stop_words | term.table < 5
term.table <- term.table[!del]
vocab <- names(term.table)

# generate format for the lda package
get.terms <- function(x) {
  index <- match(x, vocab)
  index <- index[!is.na(index)]
  rbind(as.integer(index - 1), as.integer(rep(1, length(index))))
}
documents <- lapply(doc.list, get.terms)

# model fitting
D <- length(documents)  # number of documents
W <- length(vocab)  # number of terms in the vocab
doc.length <- sapply(documents, function(x) sum(x[2, ]))  # number of tokens per
document
N <- sum(doc.length)  # total number of tokens in the data
term.frequency <- as.integer(term.table)  # frequencies of terms in the corpus


# MCMC and model tuning parameters
K <- 6 #number of topics
G <- 5000 #number of iterations; 5000
alpha <- 0.02
eta <- 0.02

# Fit the model
library(lda)
set.seed(357)
t1 <- Sys.time()
fit <- lda.collapsed.gibbs.sampler(documents = documents, K = K, vocab = vocab,
                                   num.iterations = G, alpha = alpha,
                                   eta = eta, initial = NULL, burnin = 0,
                                   compute.log.likelihood = TRUE)
```

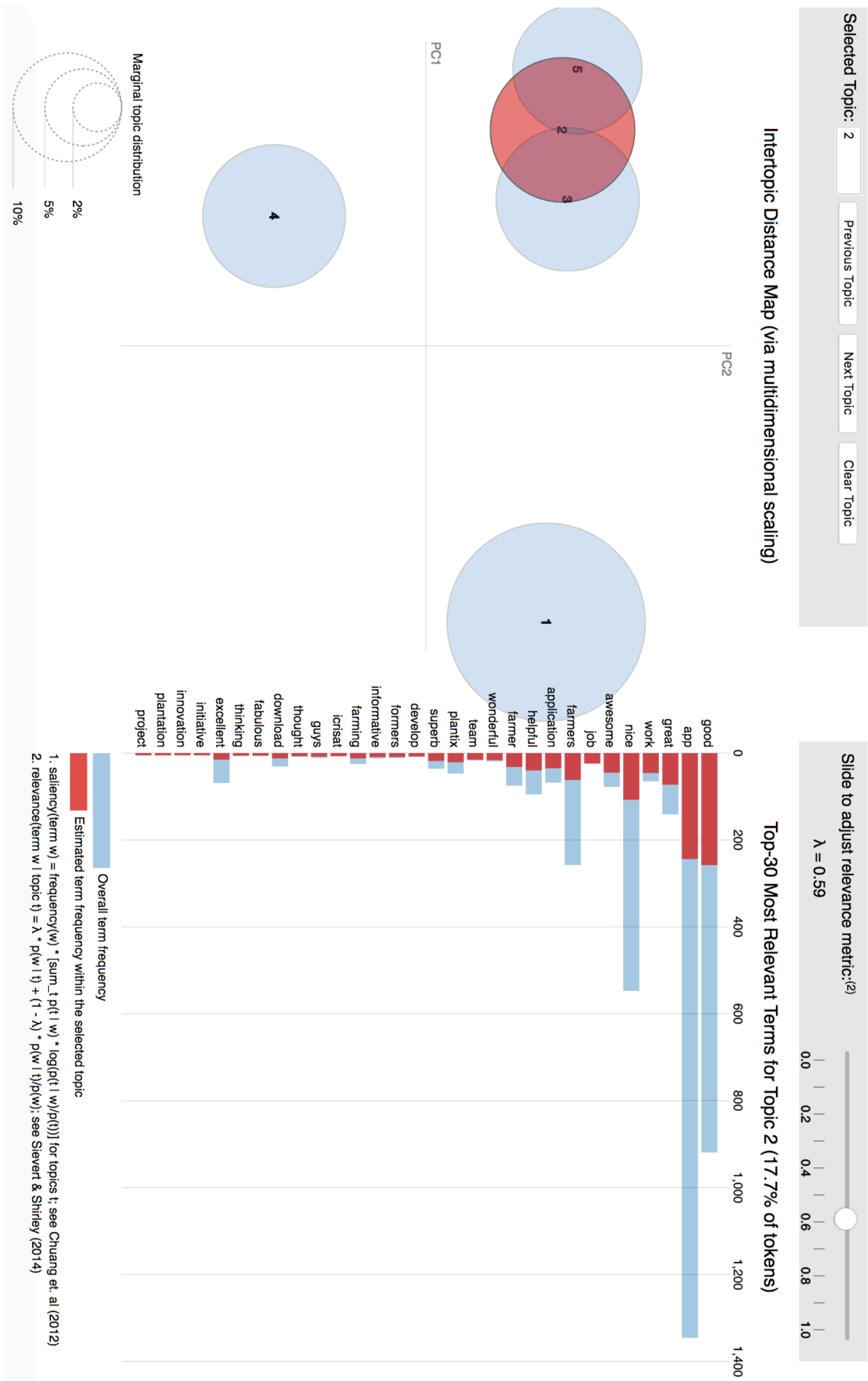
```
t2 <- Sys.time()
t2 - t1

# get theta and phi
theta <- t(apply(fit$document_sums + alpha, 2, function(x) x/sum(x)))
phi <- t(apply(t(fit$topics) + eta, 2, function(x) x/sum(x)))

AppReviews <- list(phi = phi,
                   theta = theta,
                   doc.length = doc.length,
                   vocab = vocab,
                   term.frequency = term.frequency)

# LDAvis
library(LDAvis)

# create the JSON object for the visualization
json <- createJSON(phi = AppReviews$phi,
                 theta = AppReviews$theta,
                 doc.length = AppReviews$doc.length,
                 vocab = AppReviews$vocab,
                 term.frequency = AppReviews$term.frequency)

# generate files in folder: /vis/
serVis(json, out.dir = 'vis', open.browser = FALSE)
```

9.5 LDAvis for reviews and articles about the Plantix app

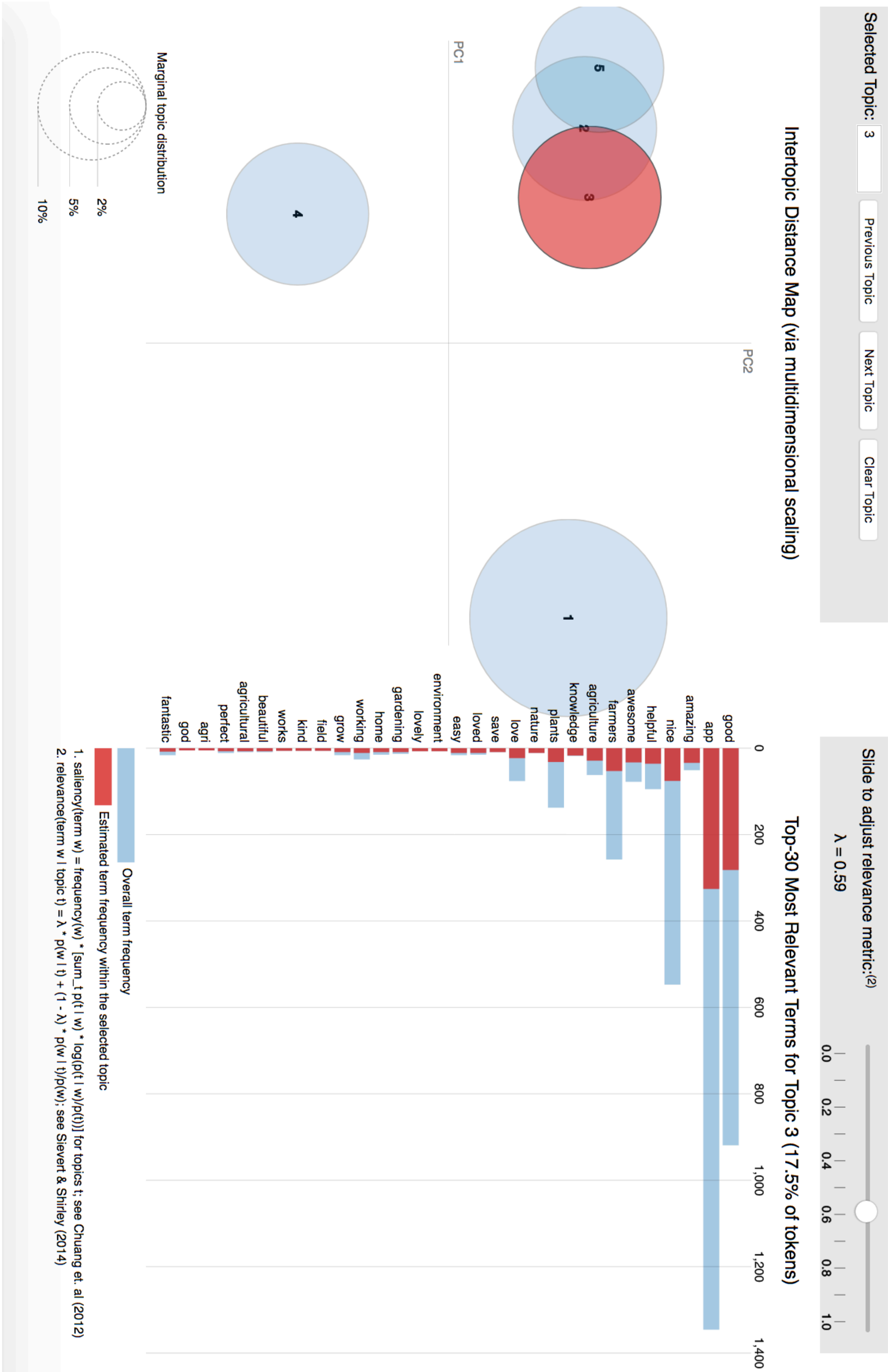
Size of the topics of the reviews in English. Most frequent terms for topic 1



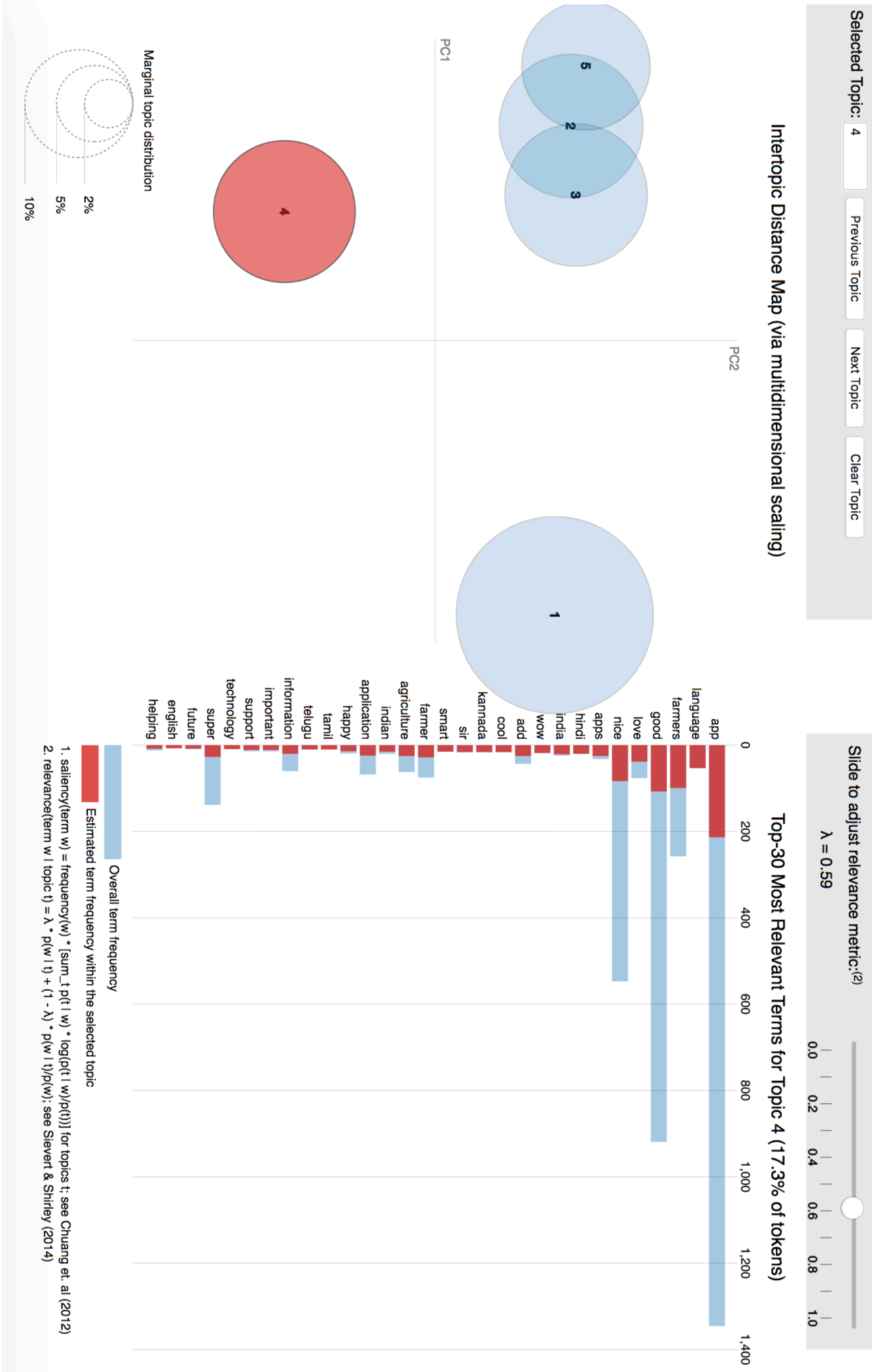
Size of the topics of the reviews in English. Most frequent terms for topic 2



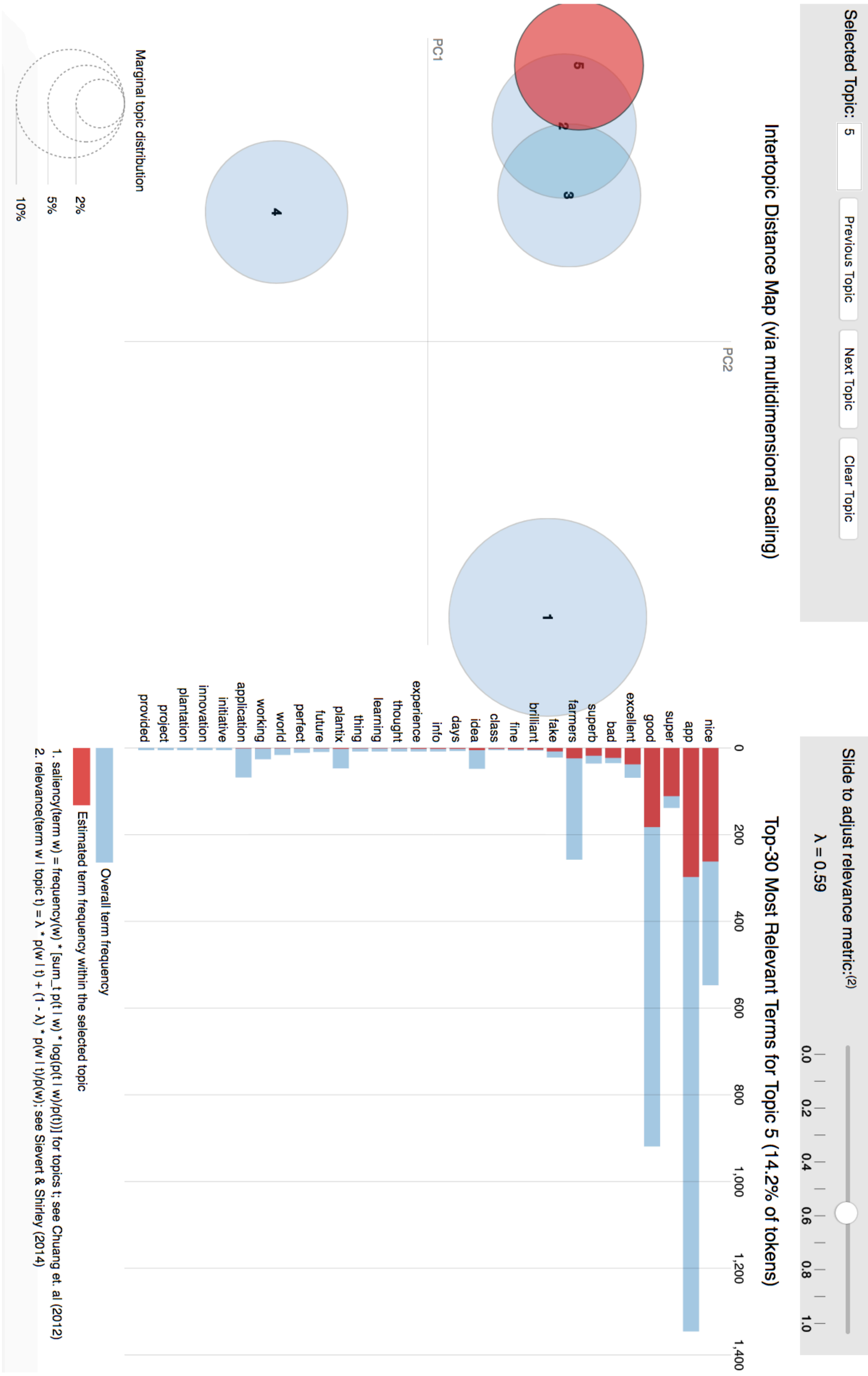
Size of the topics of the reviews in English. Most frequent terms for topic 3



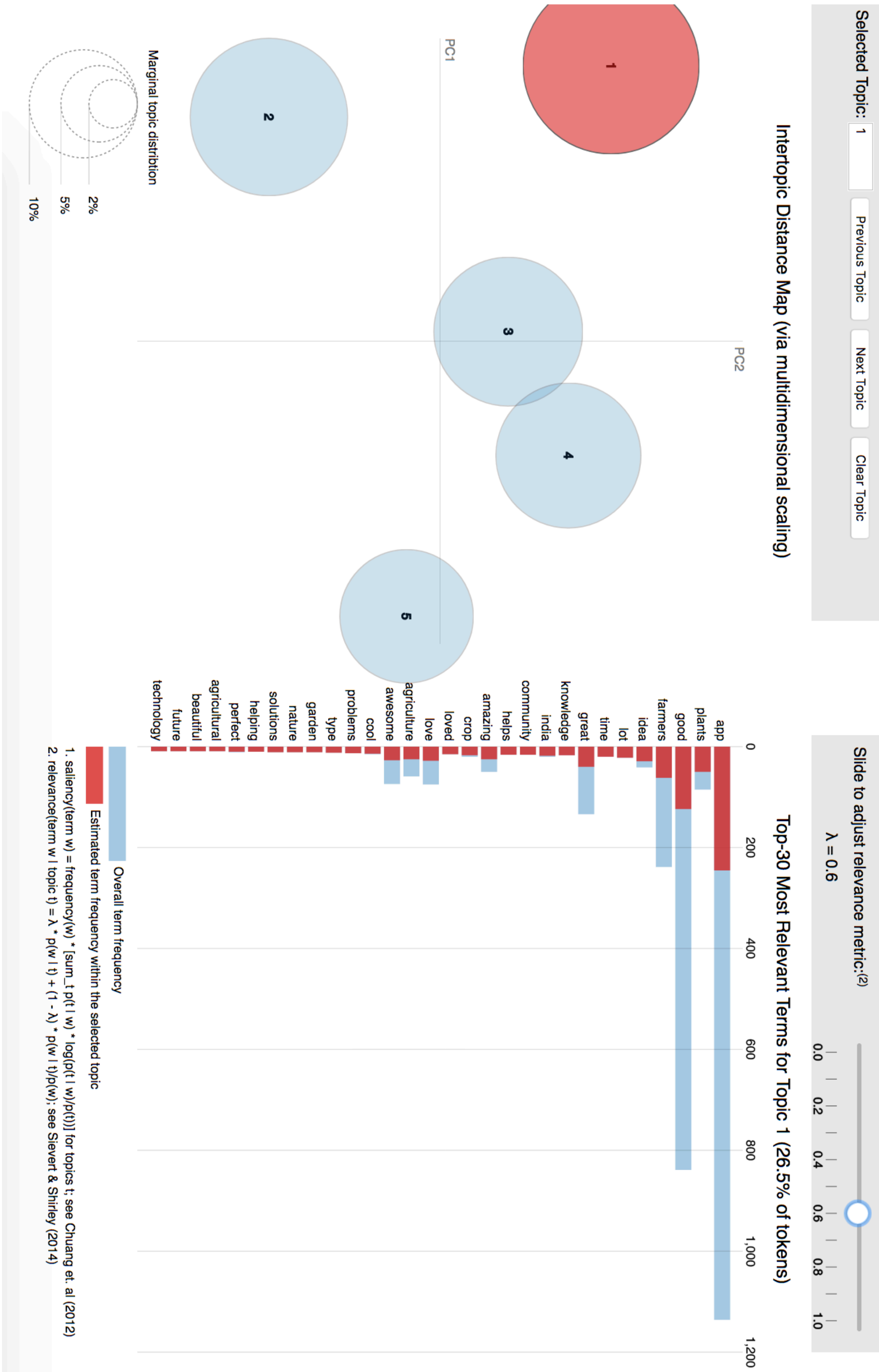
Size of the topics for the reviews in English. Most frequent terms for topic 4



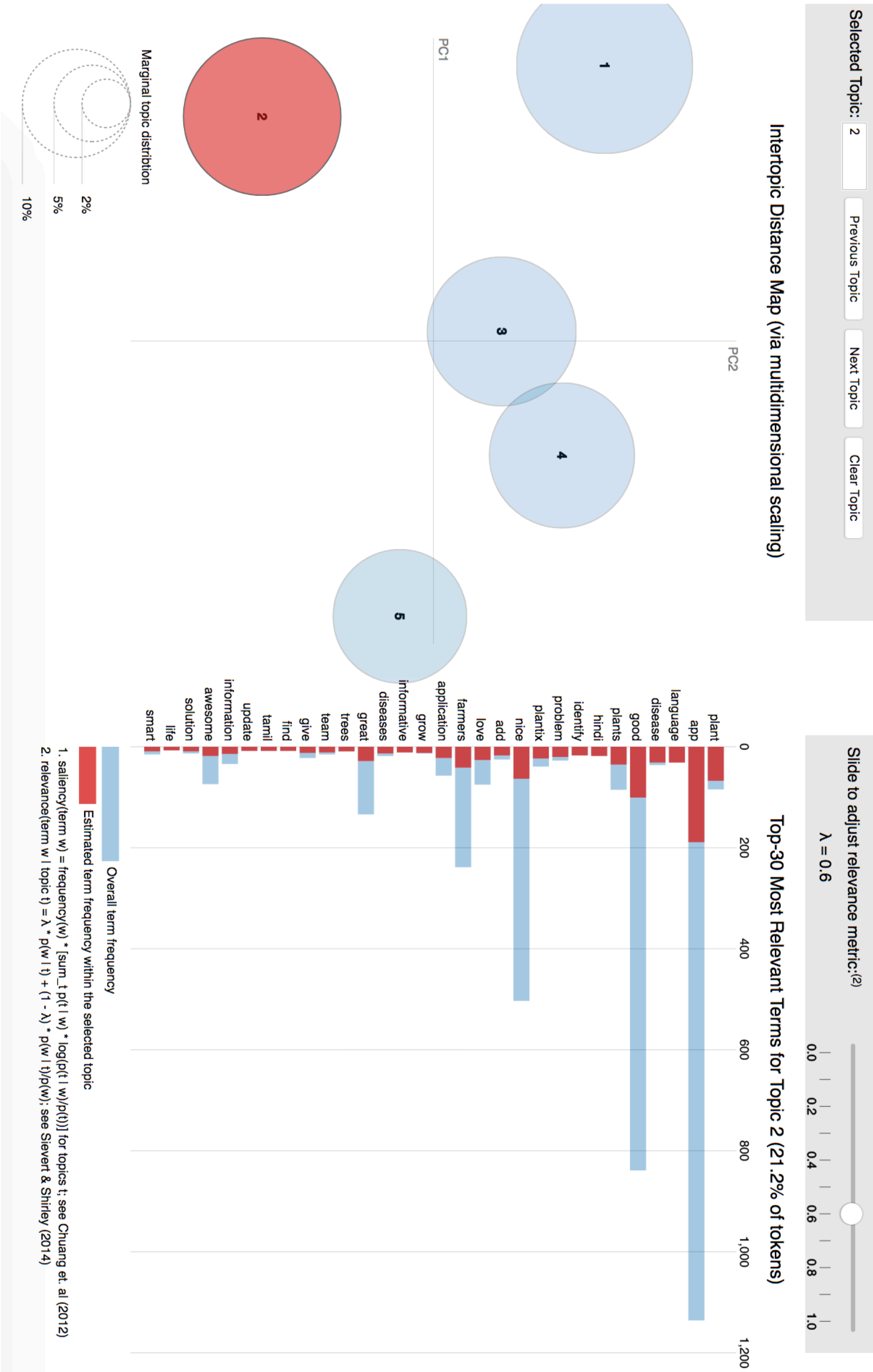
Size of the topics for the reviews in English. Most frequent terms for topic 5



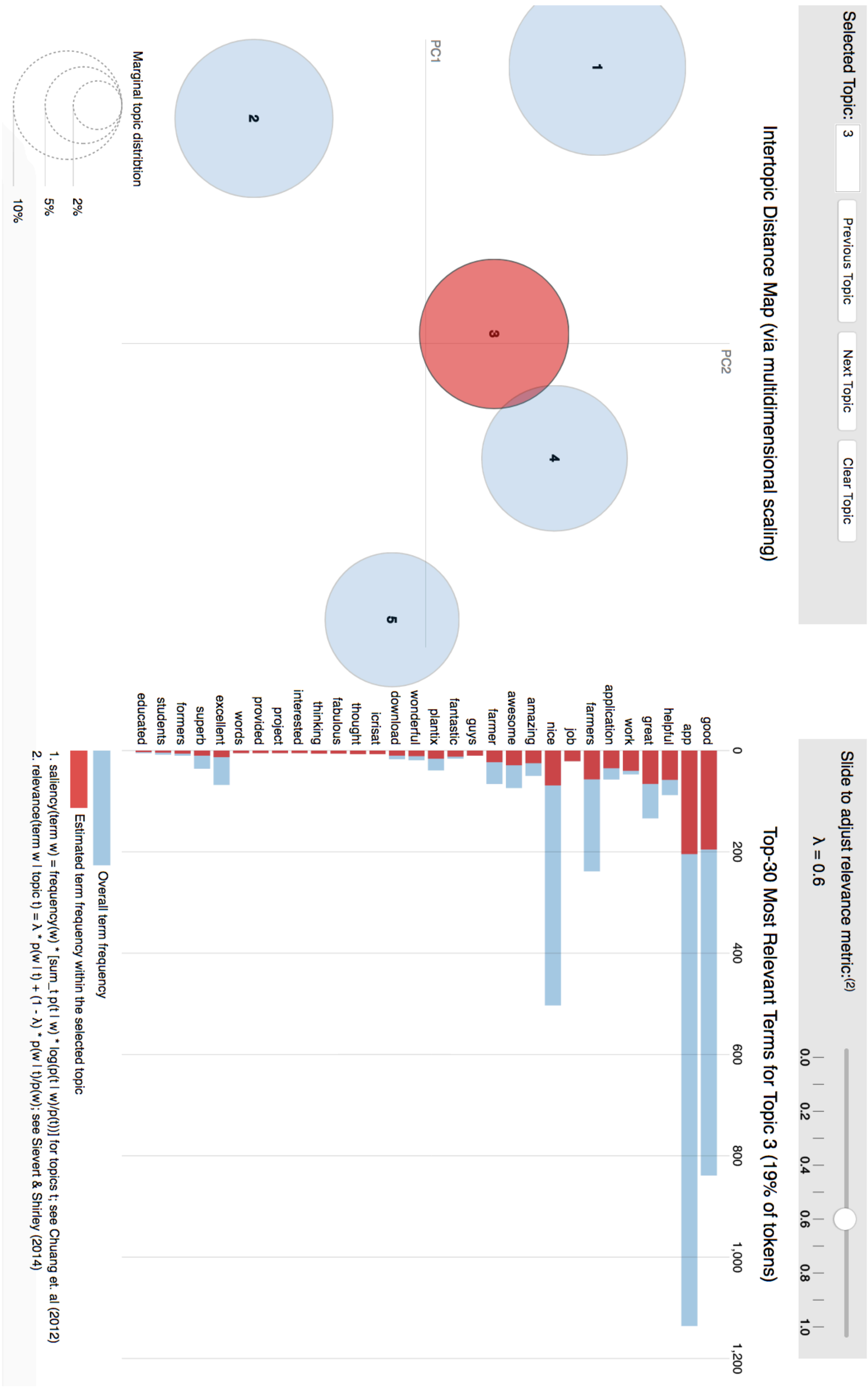
Size of the topics for the positive reviews in English. Most frequent terms for topic 1



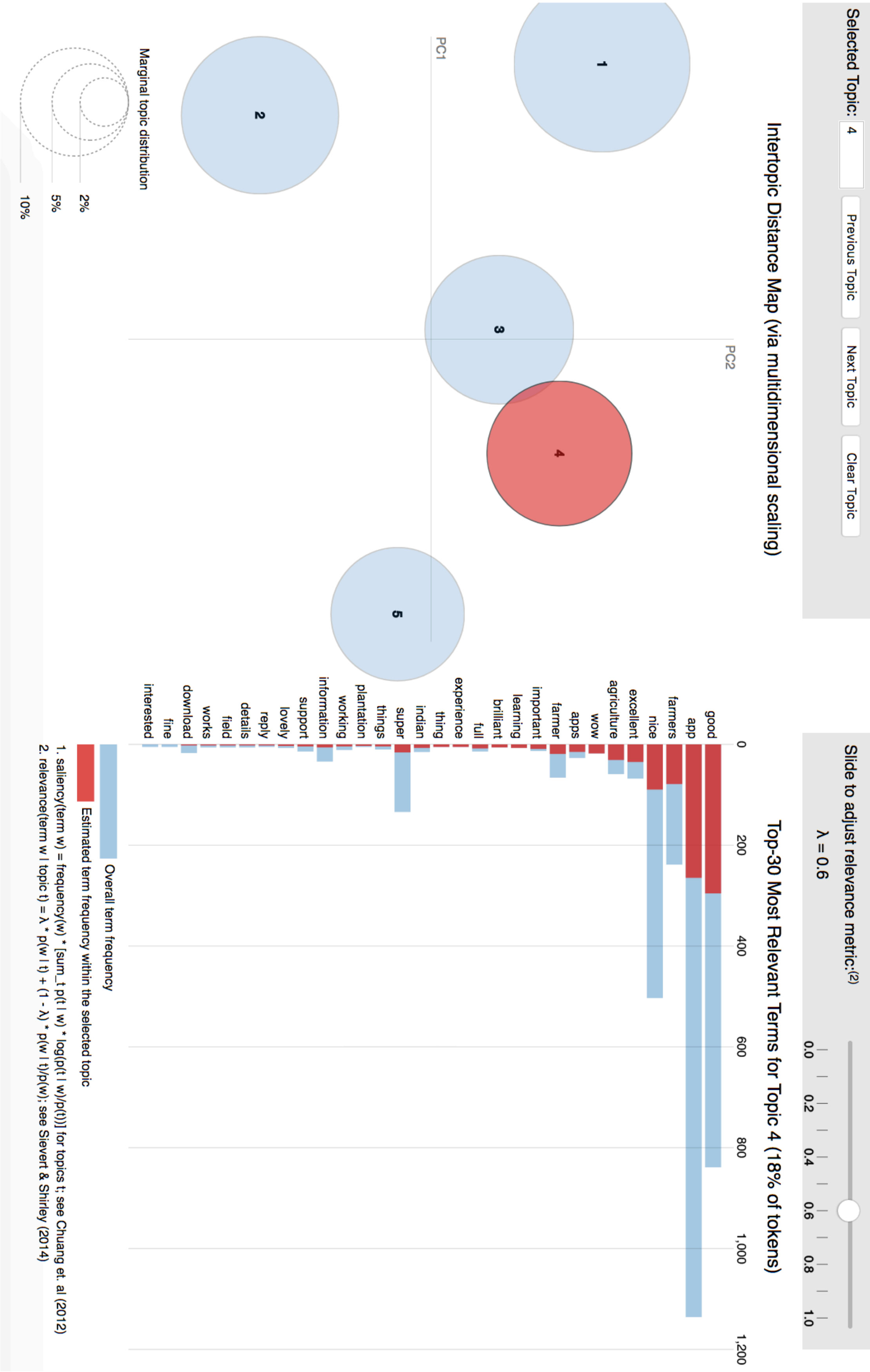
Size of the topics for the positive reviews in English. Most frequent terms for topic 2



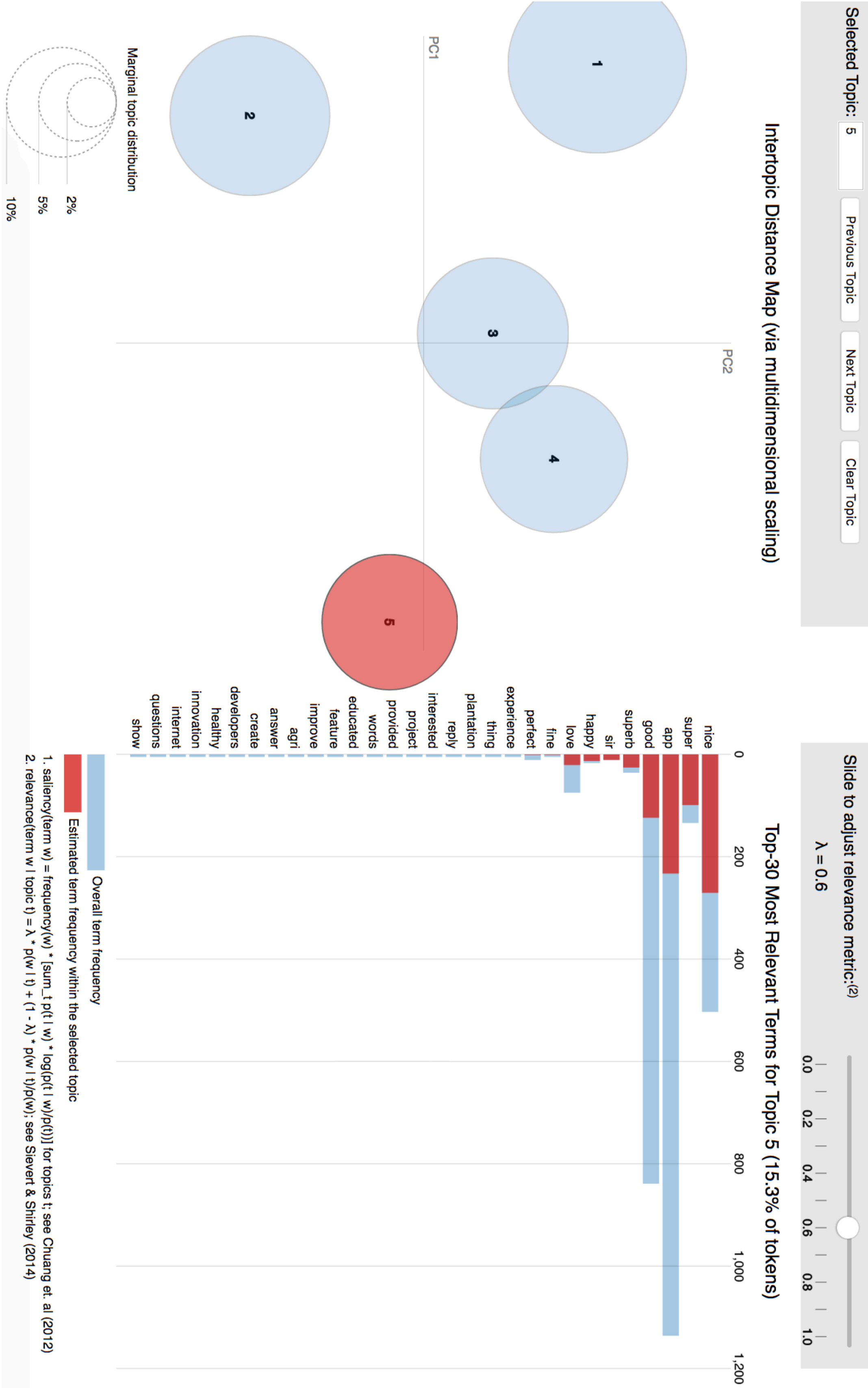
Size of the topics for the positive reviews in English. Most frequent terms for topic 3



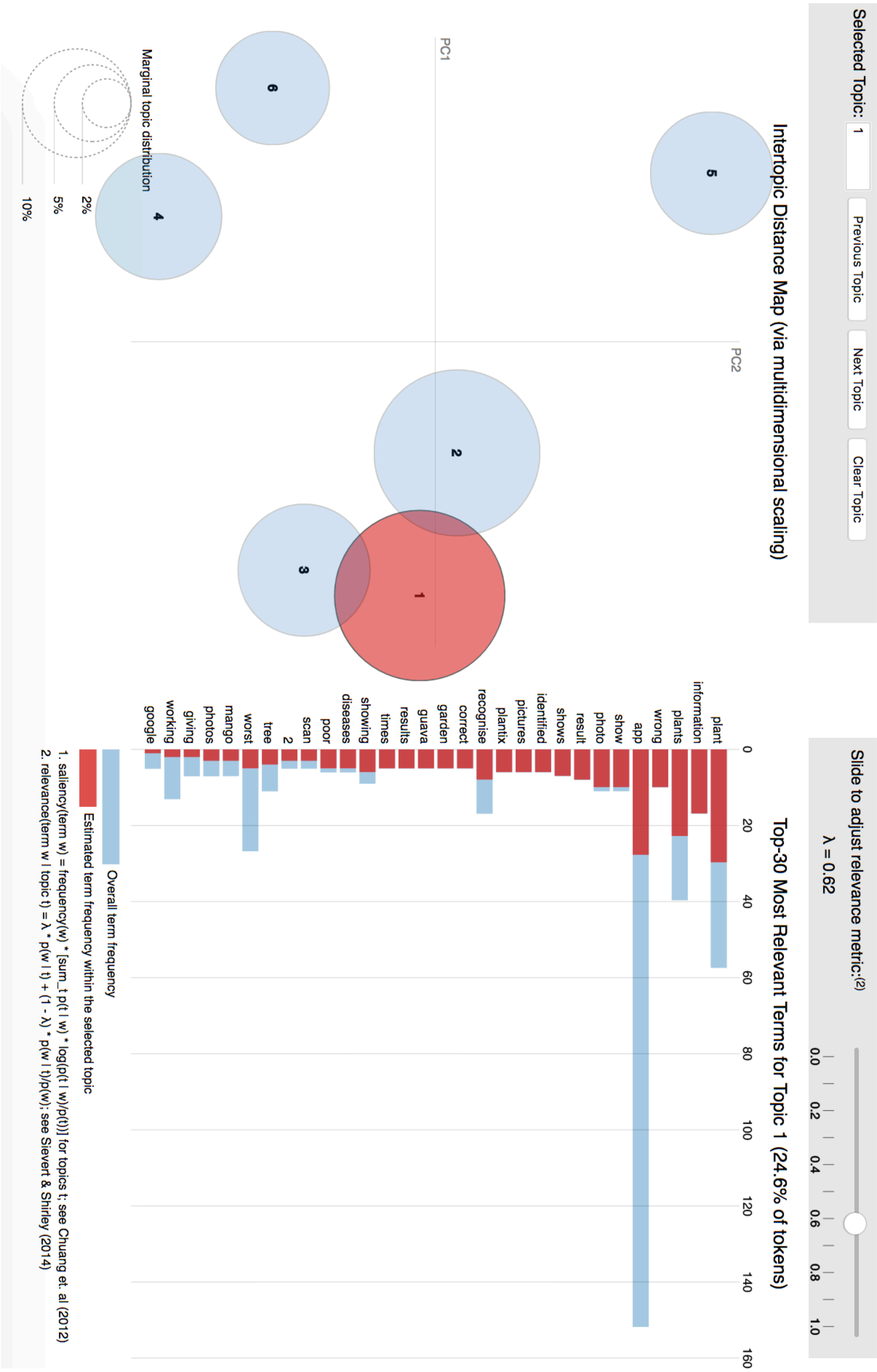
Size of the topics for the positive reviews in English. Most frequent terms for topic 4



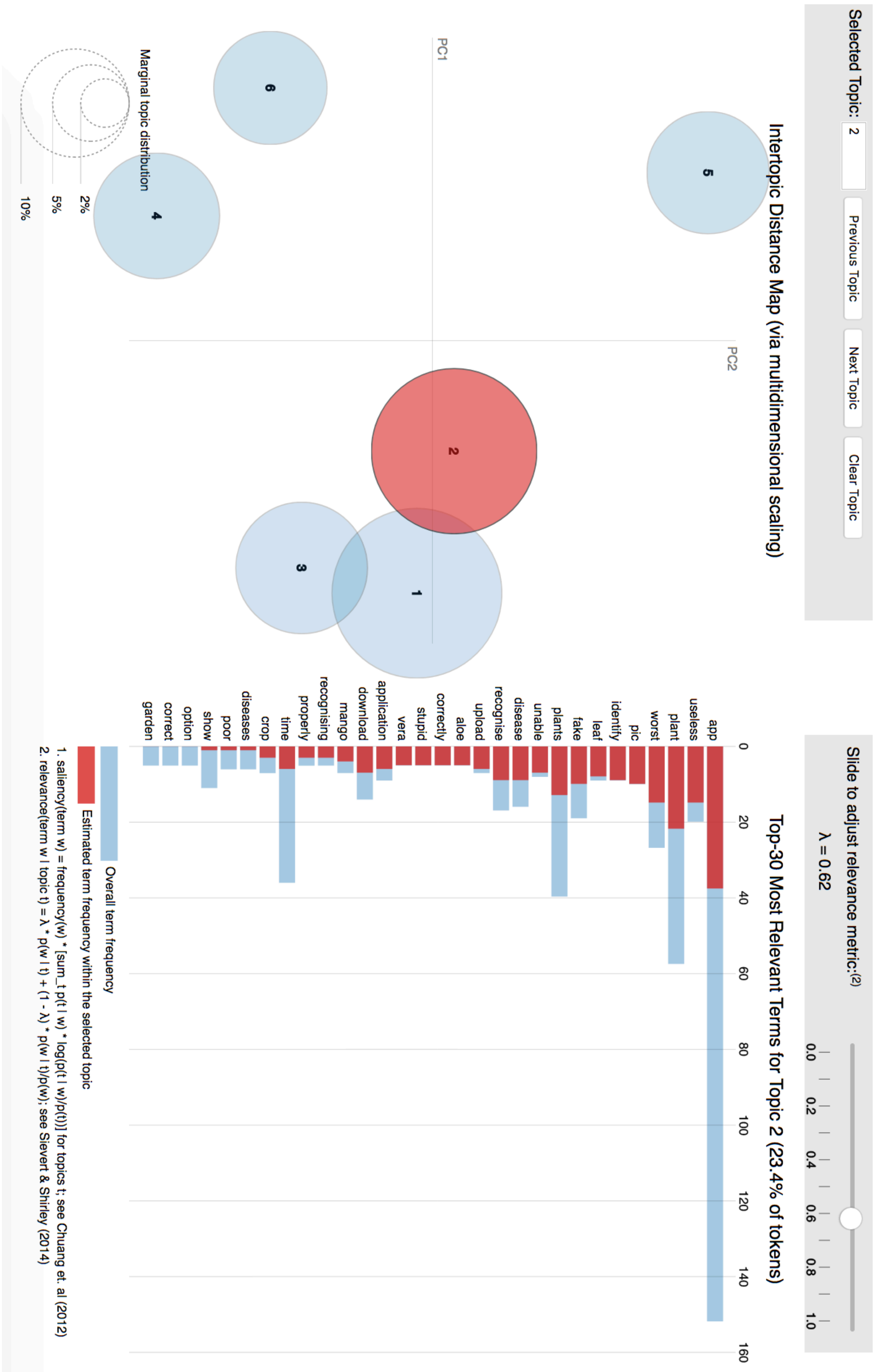
Size of the topics for the positive reviews in English. Most frequent terms for topic 5



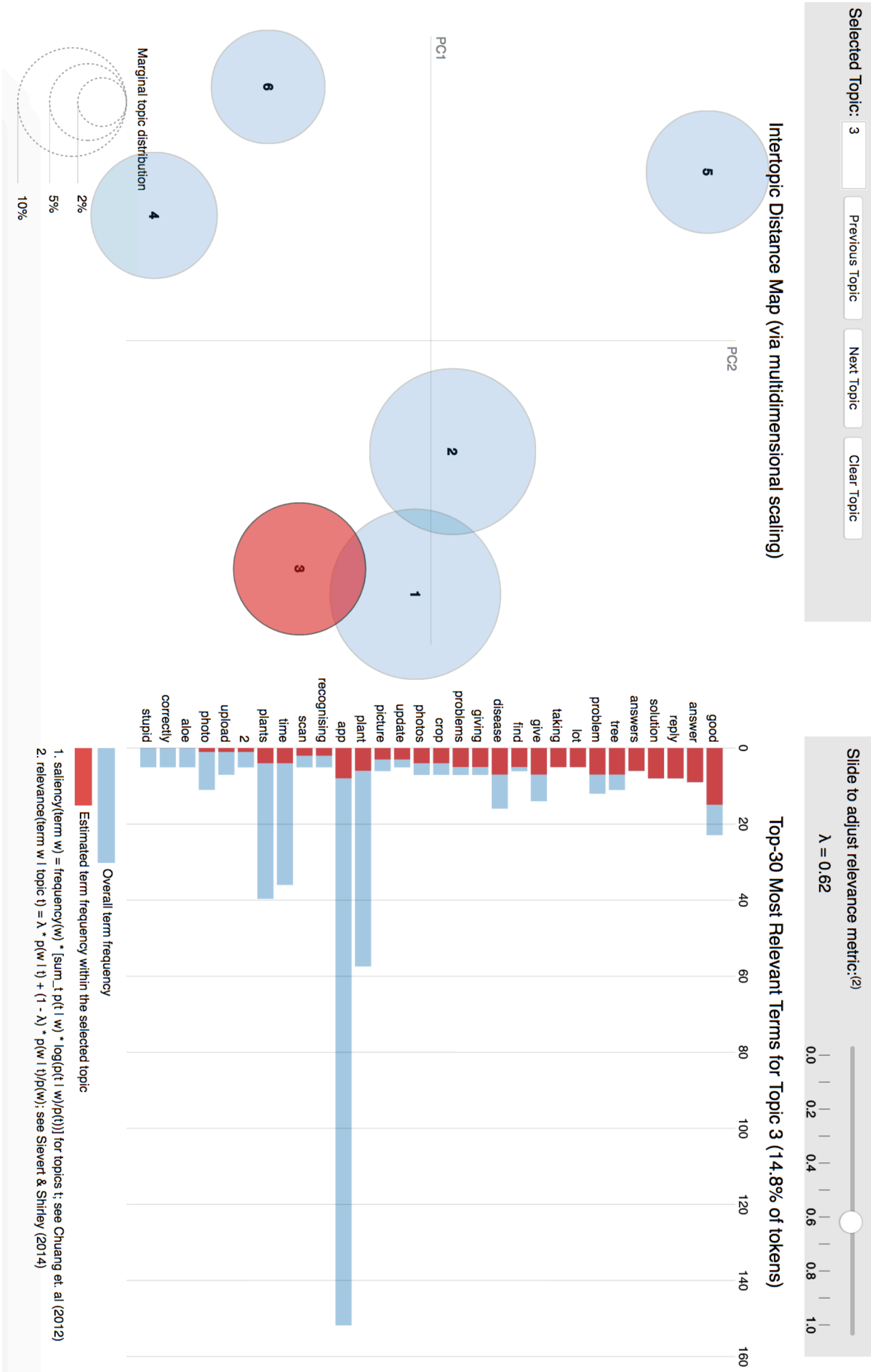
Size of the topics for the negative reviews in English. Most frequent terms for topic 1



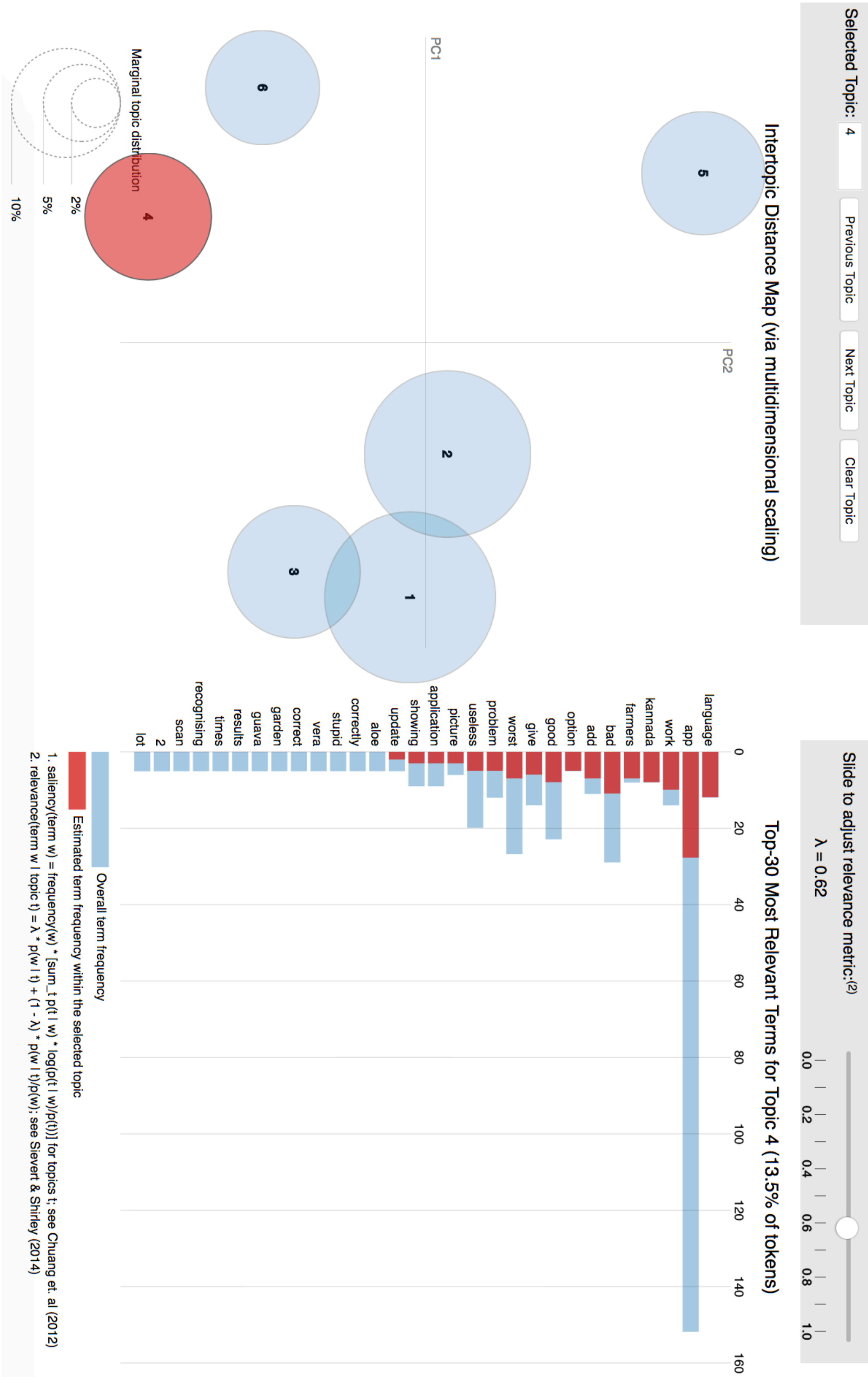
Size of the topics for the negative reviews in English. Most frequent terms for topic 2



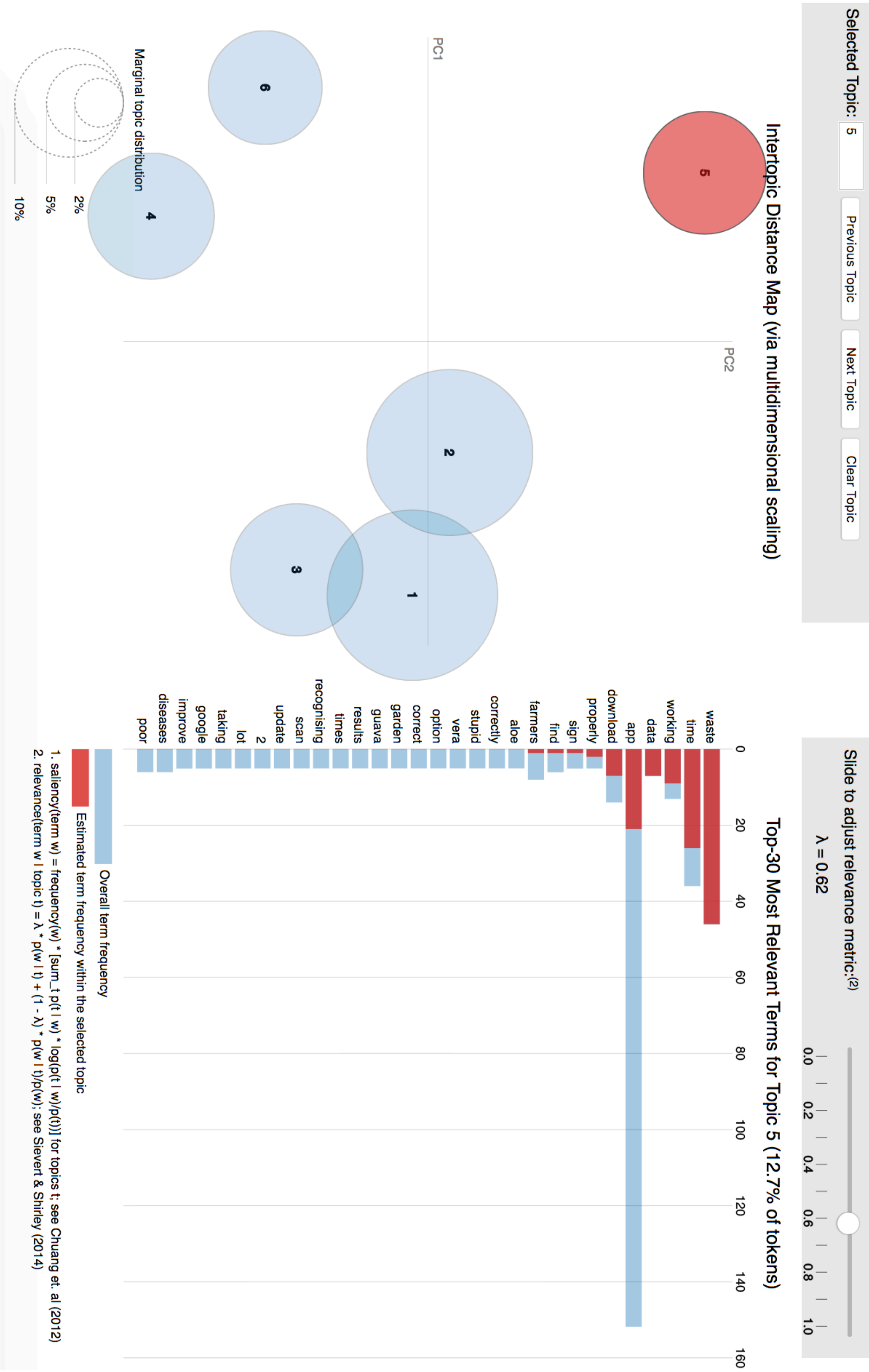
Size of the topics for the negative reviews in English. Most frequent terms for topic 3



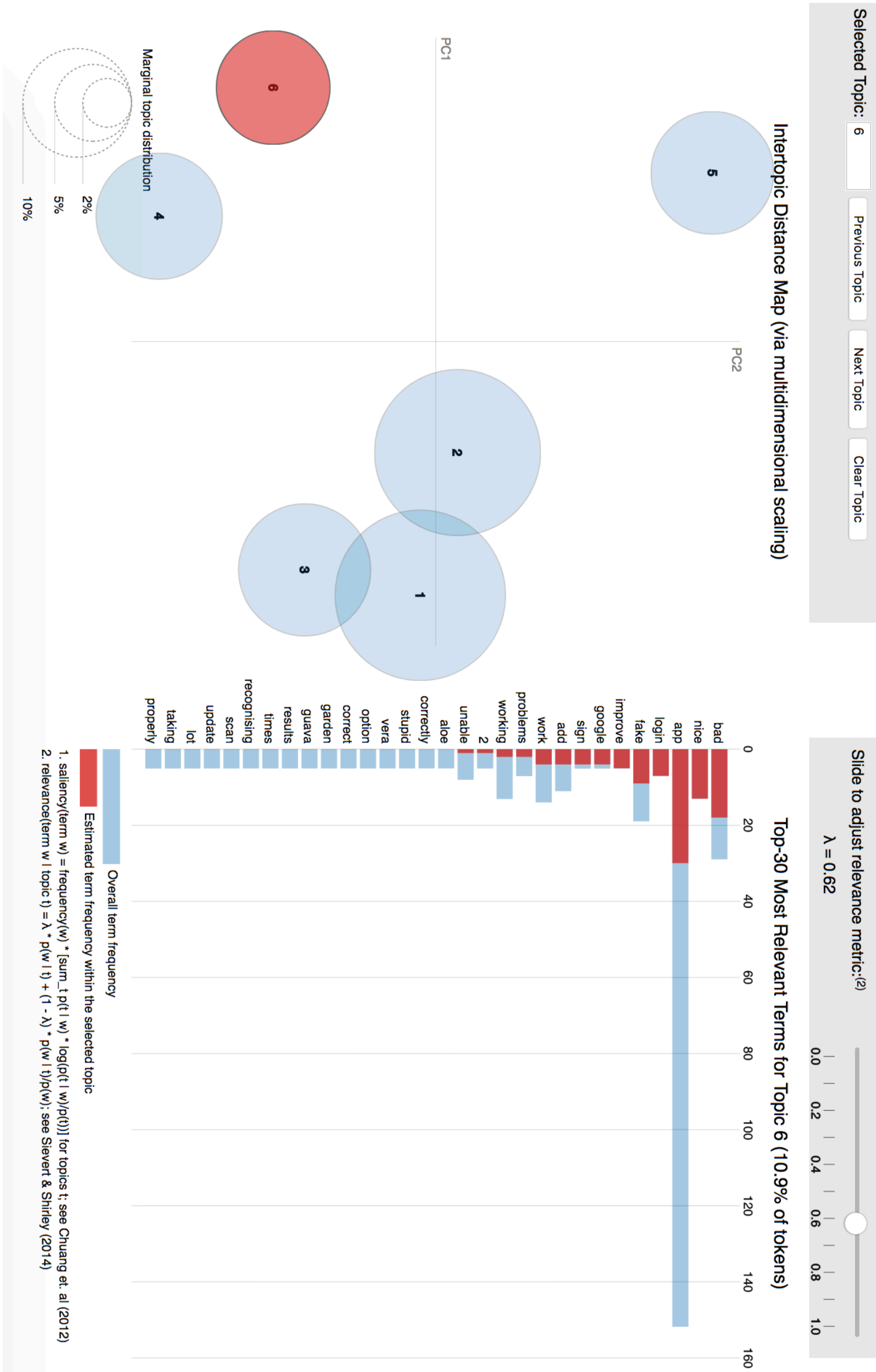
Size of the topics for the negative reviews in English. Most frequent terms for topic 4



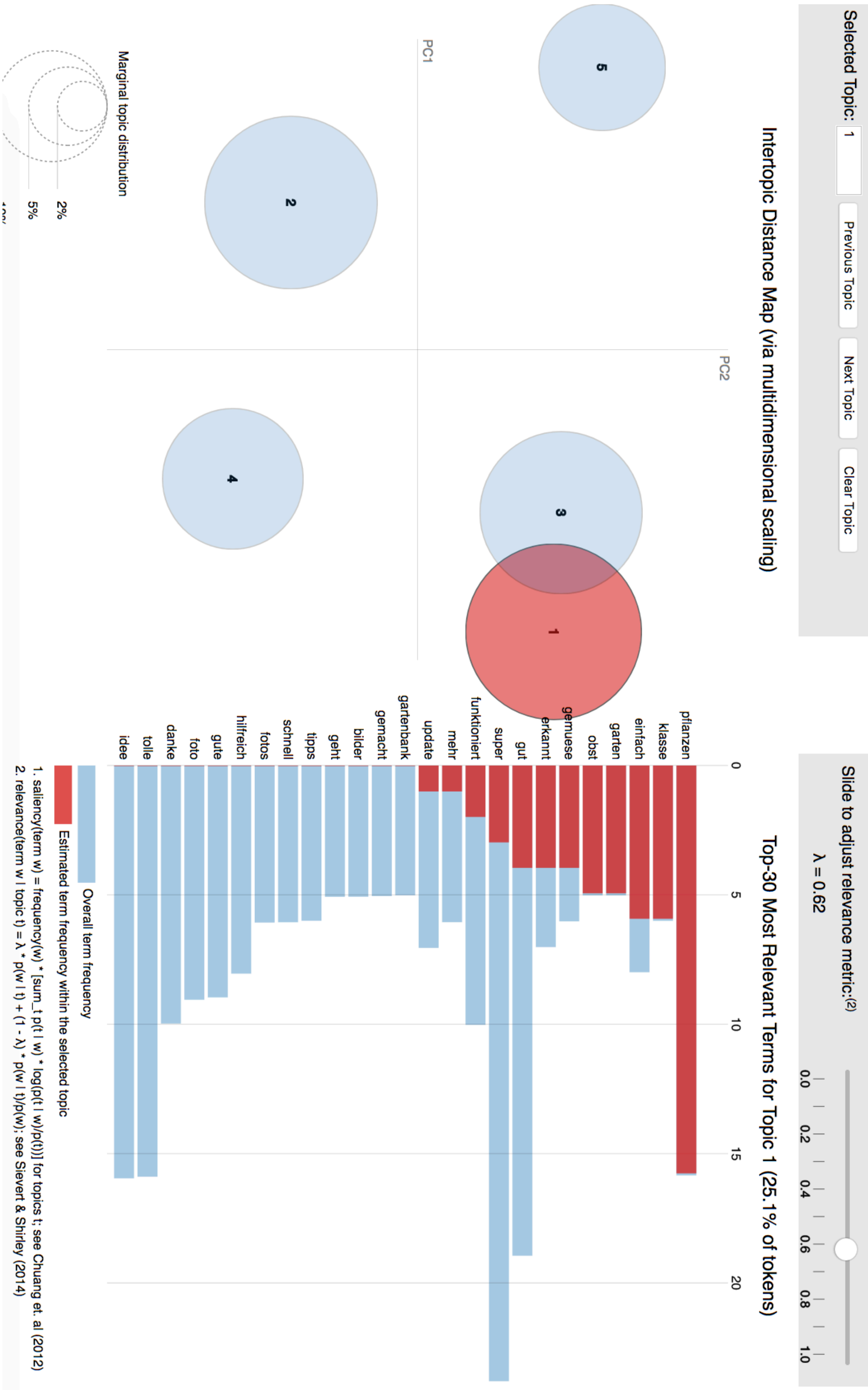
Size of the topics for the negative reviews in English. Most frequent terms for topic 5



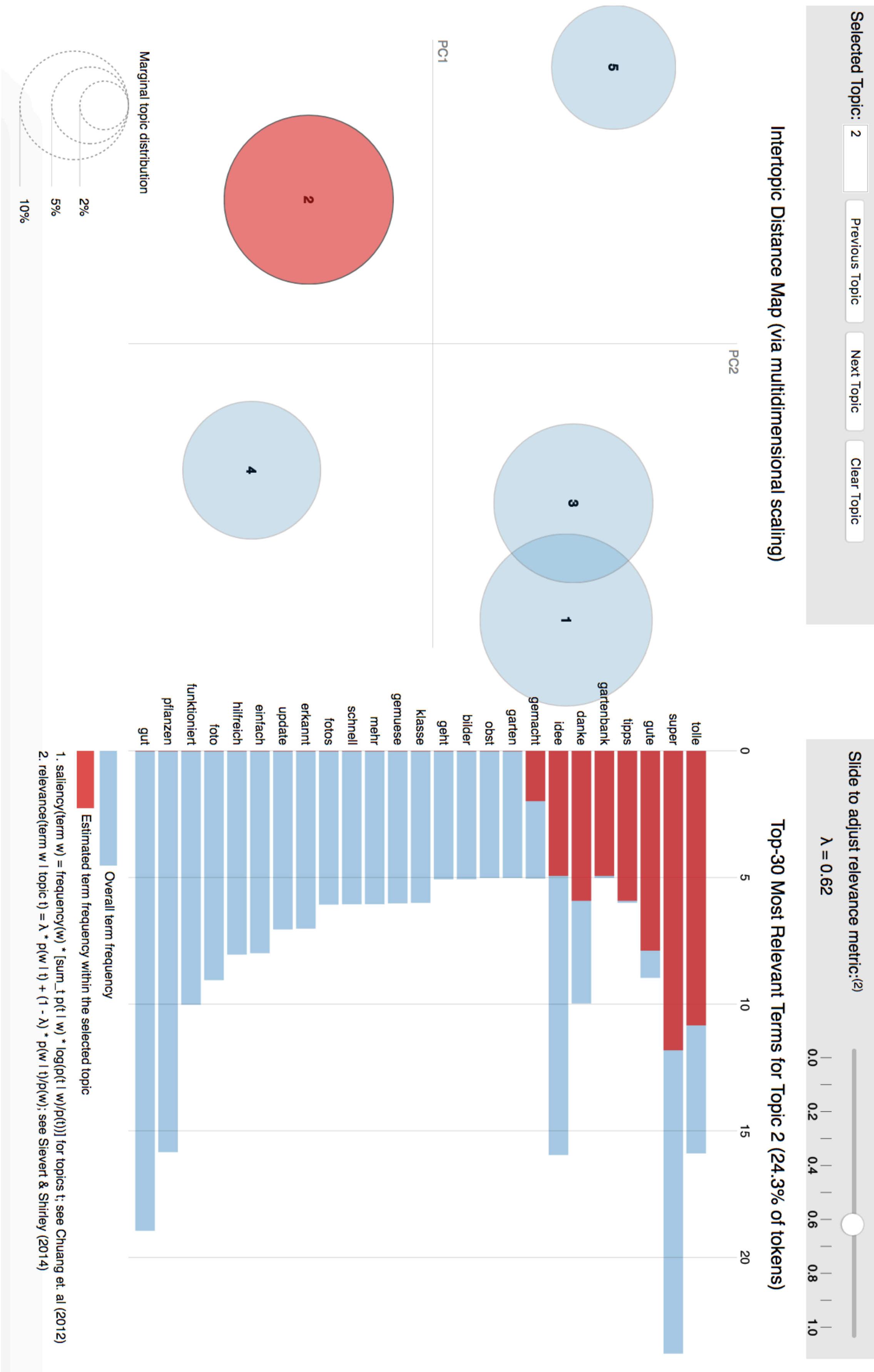
Size of the topics for the negative reviews in English. Most frequent terms for topic 6



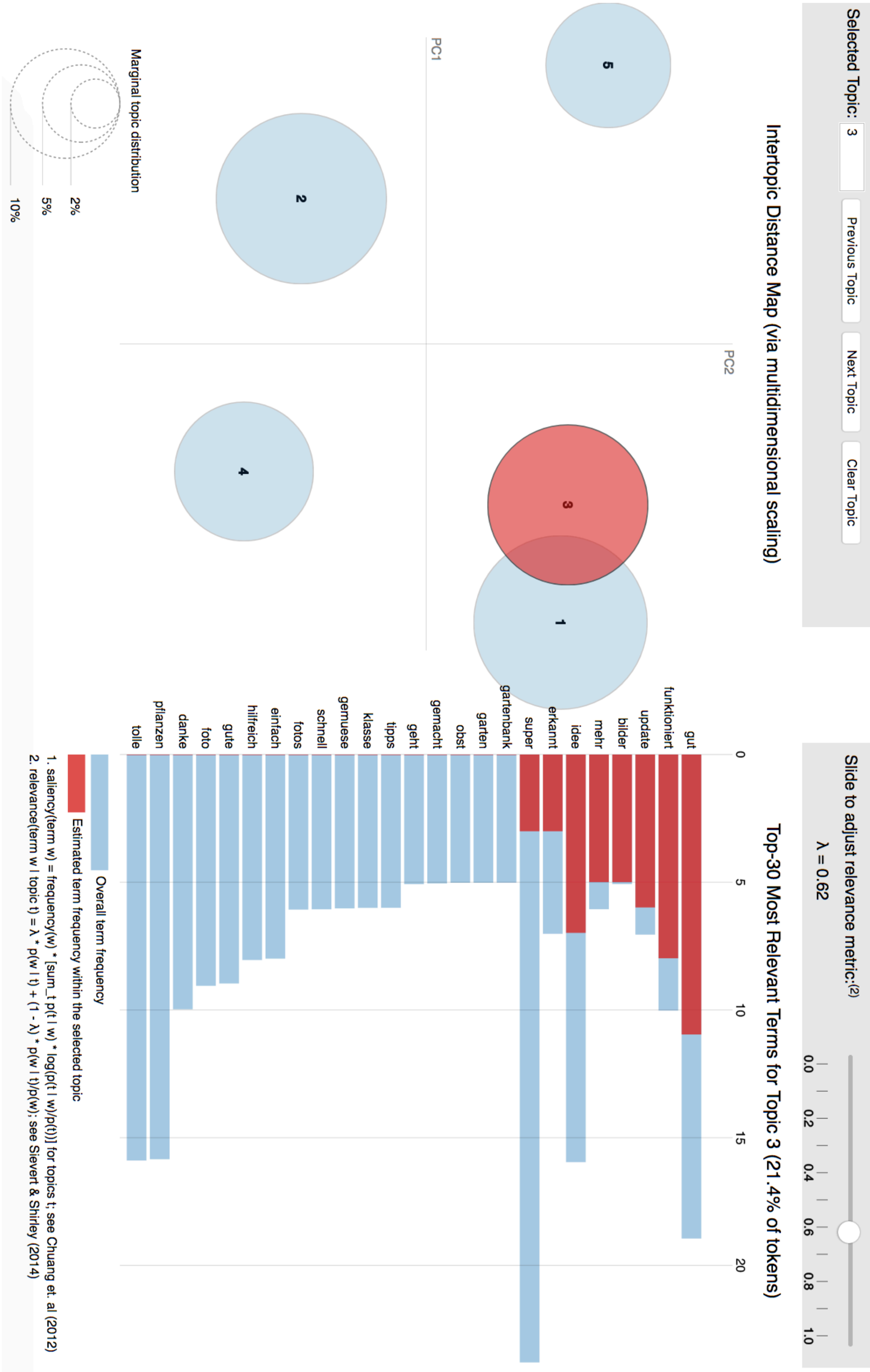
Size of the topics for the reviews in German. Most frequent terms for topic 1



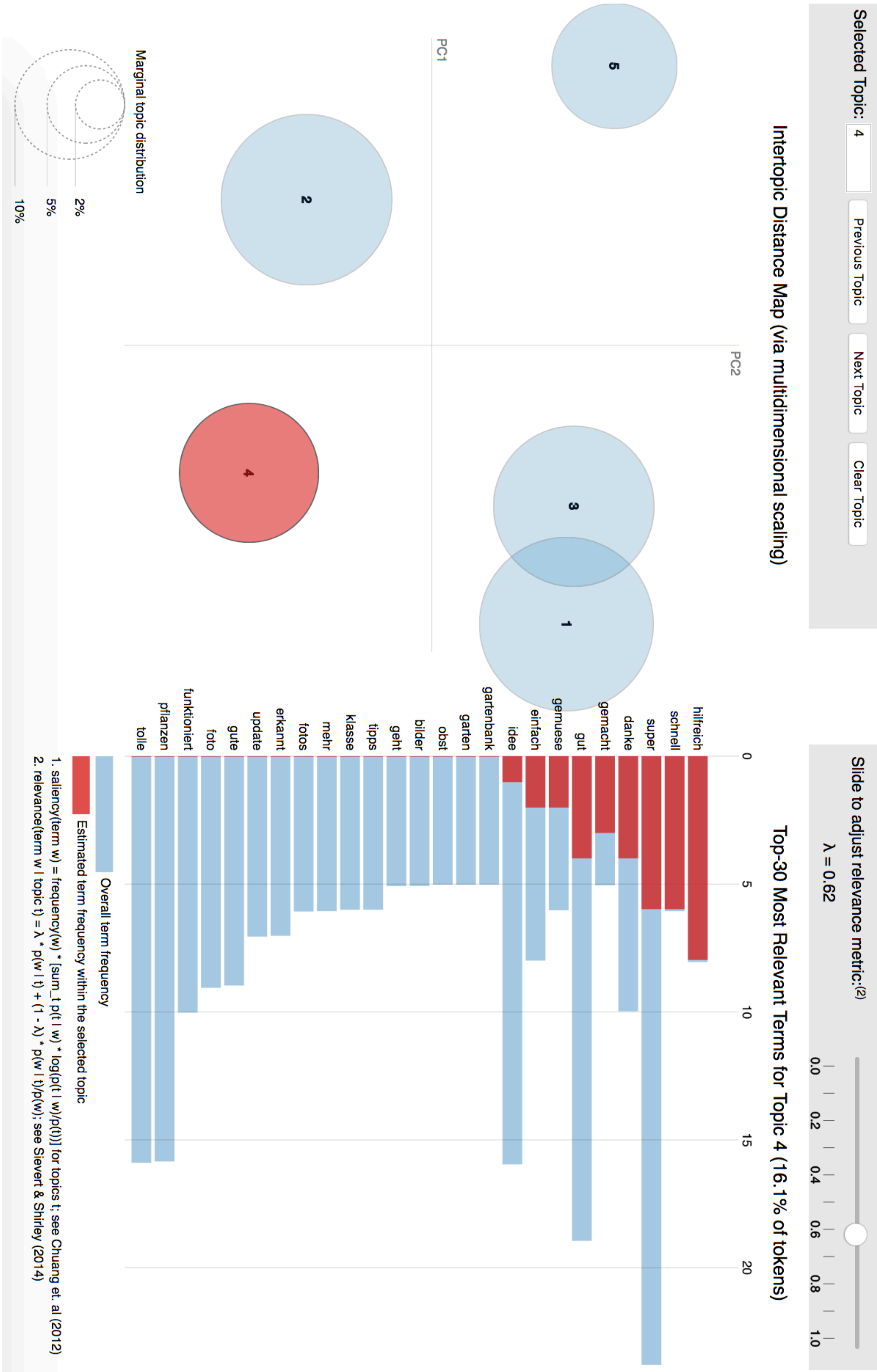
Size of the topics for the reviews in German. Most frequent terms for topic 2



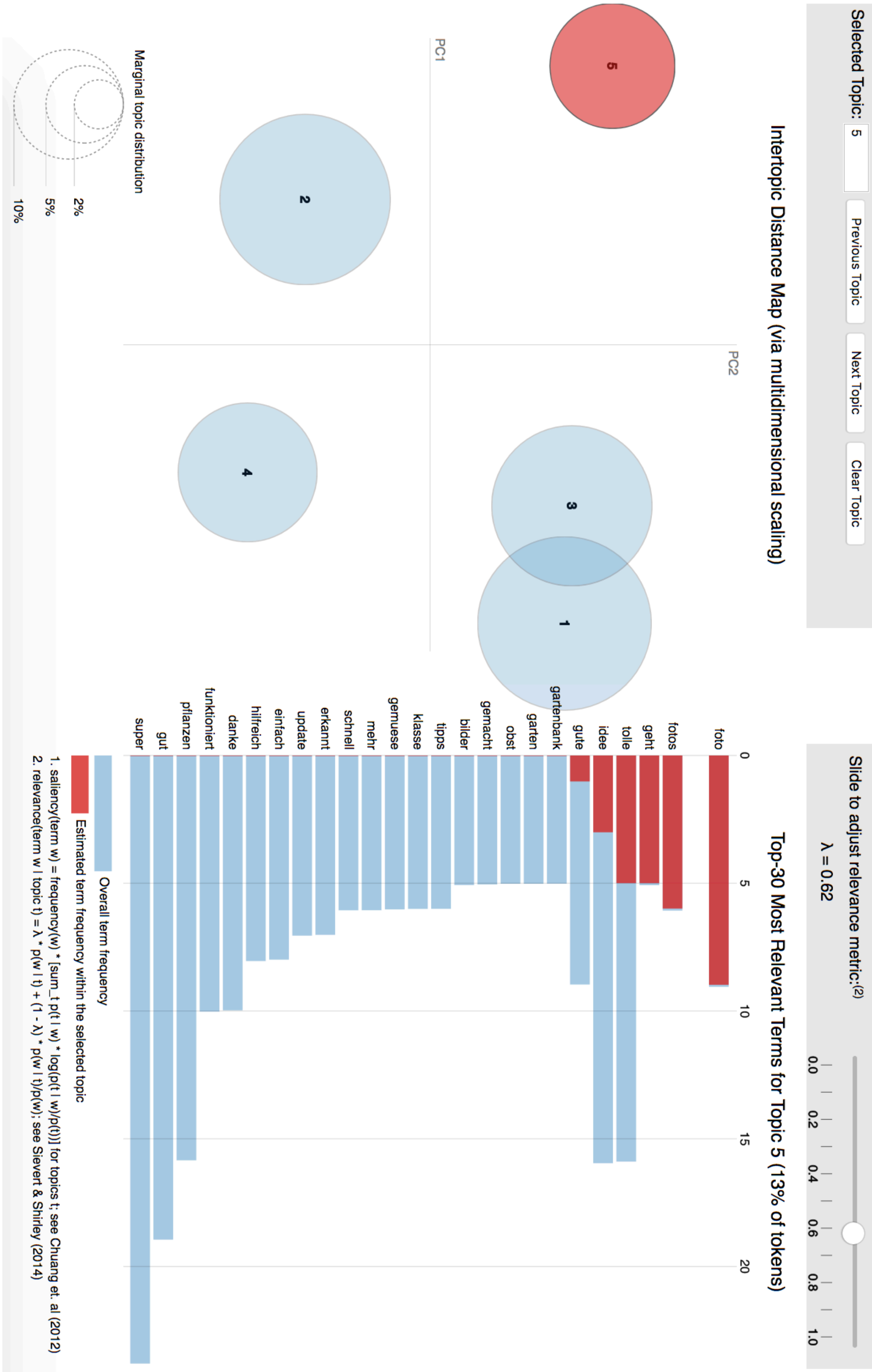
Size of the topics for the reviews in German. Most frequent terms for topic 3



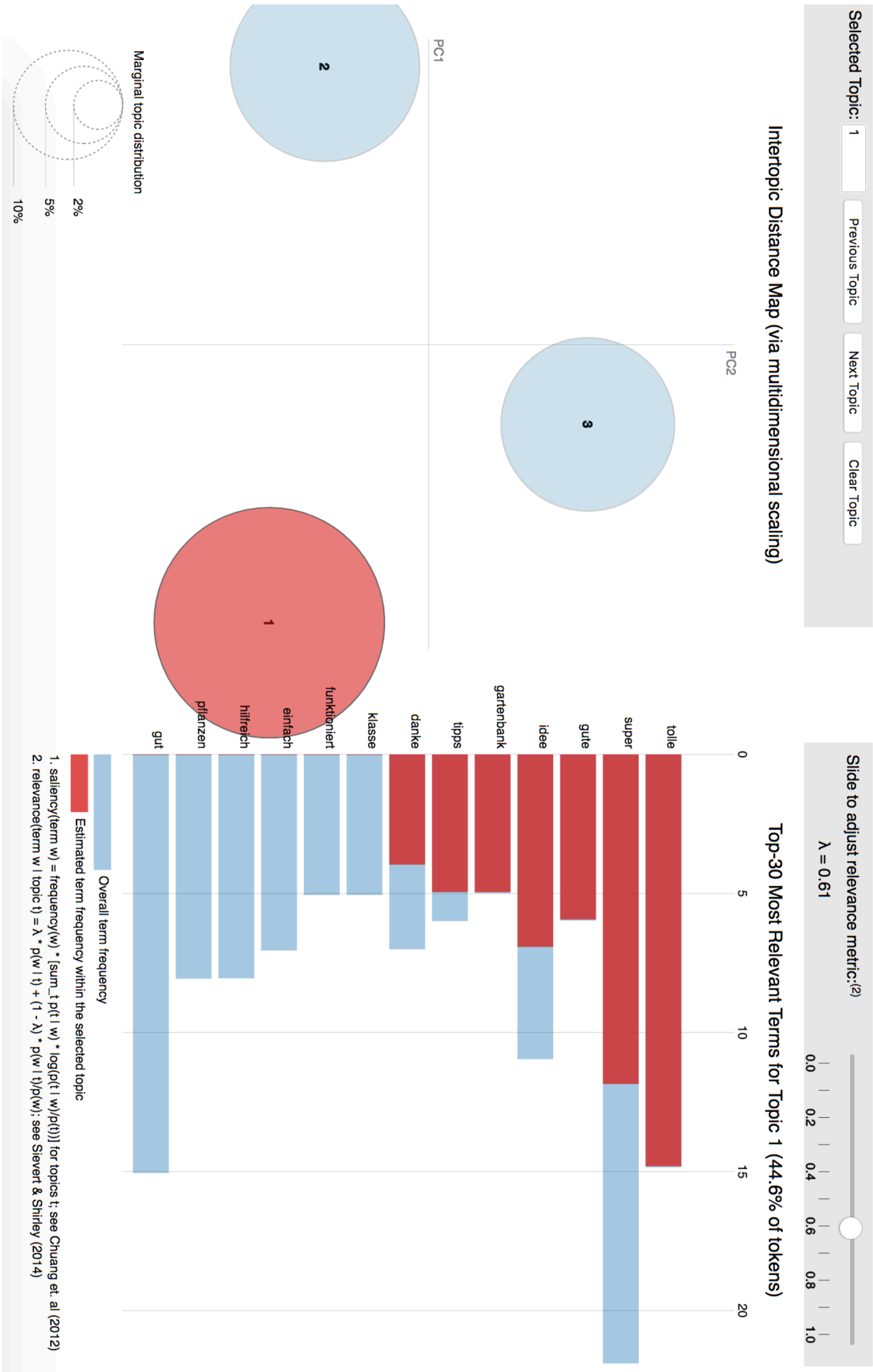
Size of the topics for the reviews in German. Most frequent terms for topic 4



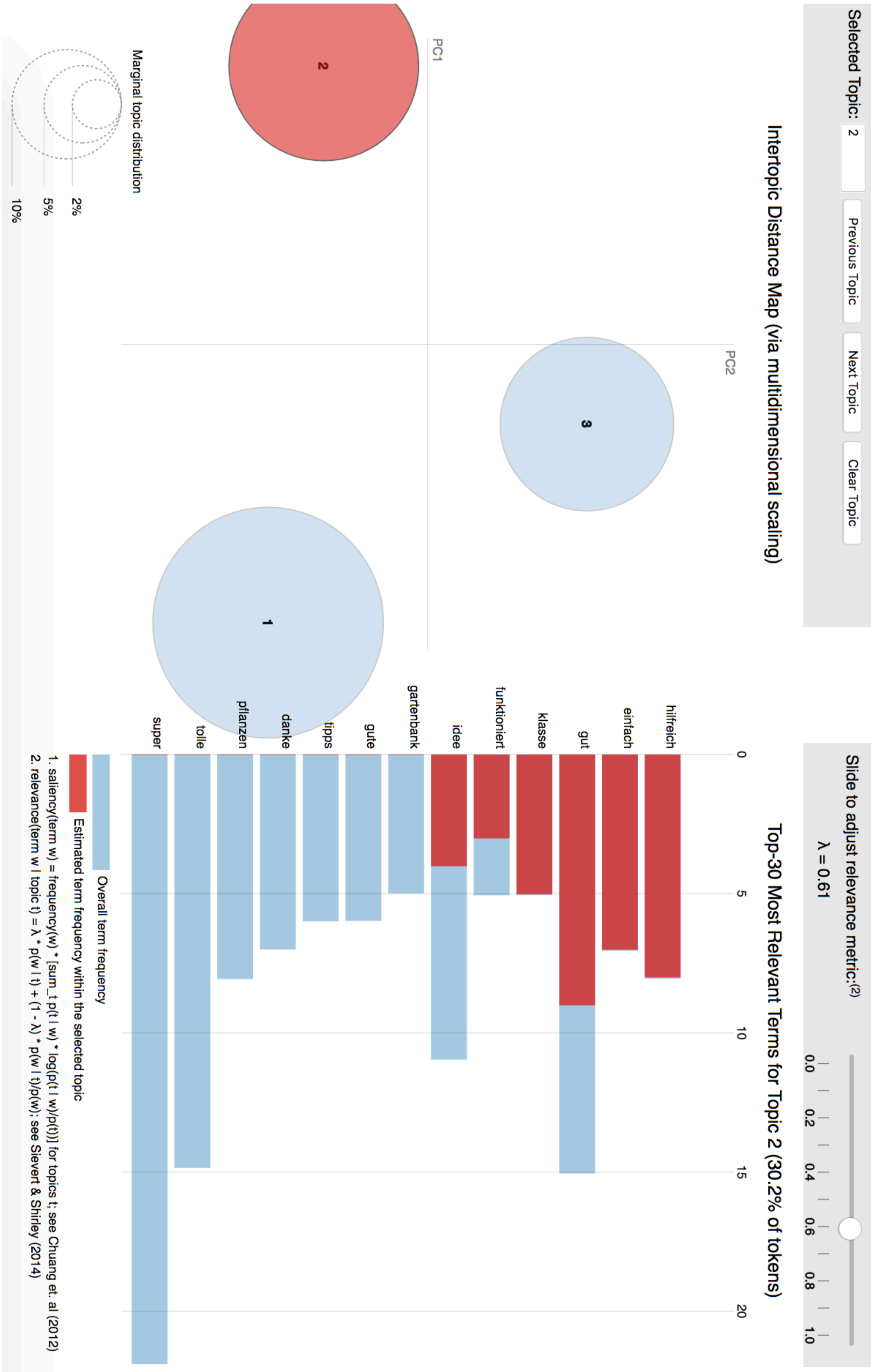
Size of the topics for the reviews in German. Most frequent terms for topic 5



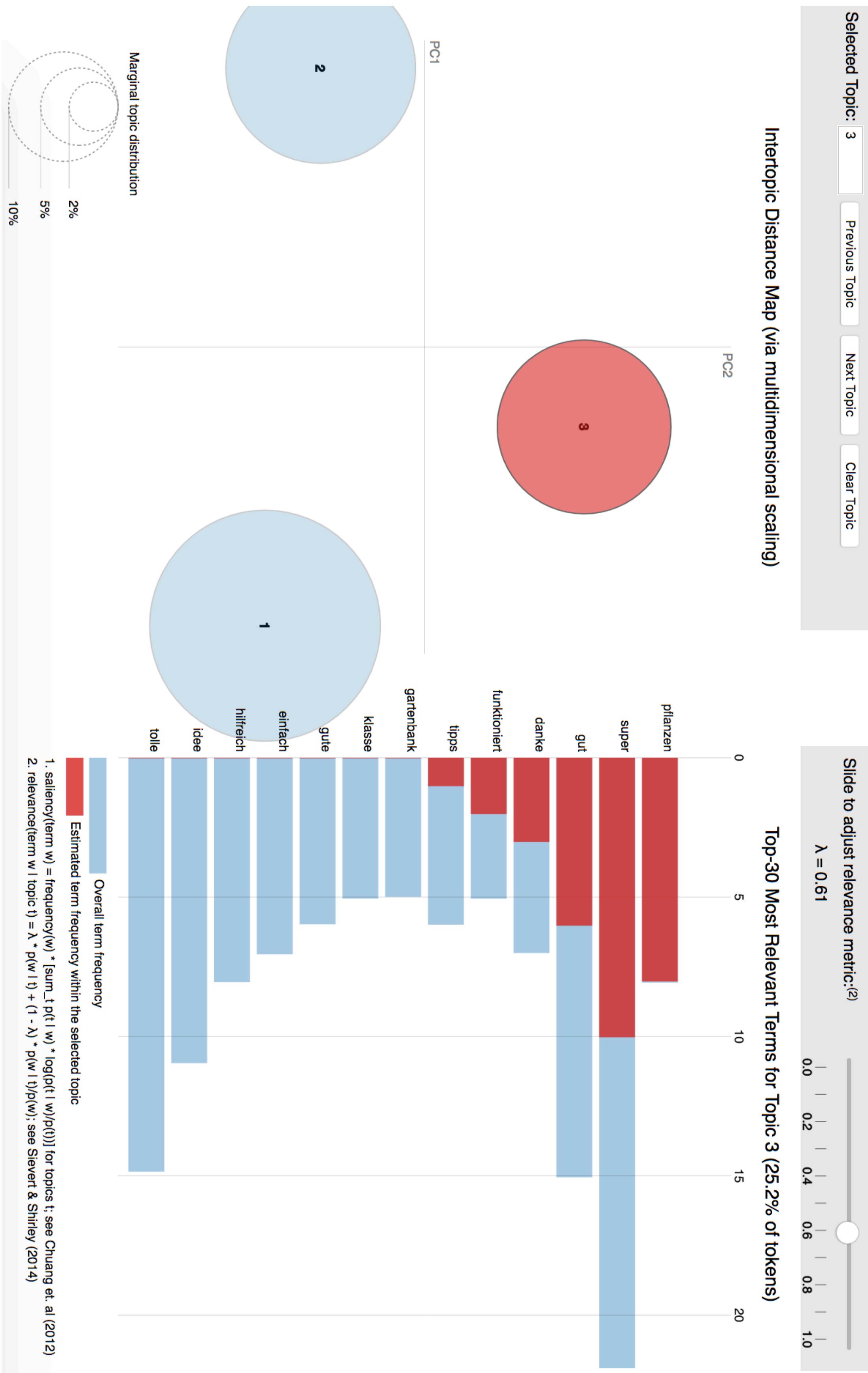
Size of the topics for the positive reviews in German. Most frequent terms for topic 1



Size of the topics for the positive reviews in German. Most frequent terms for topic 2

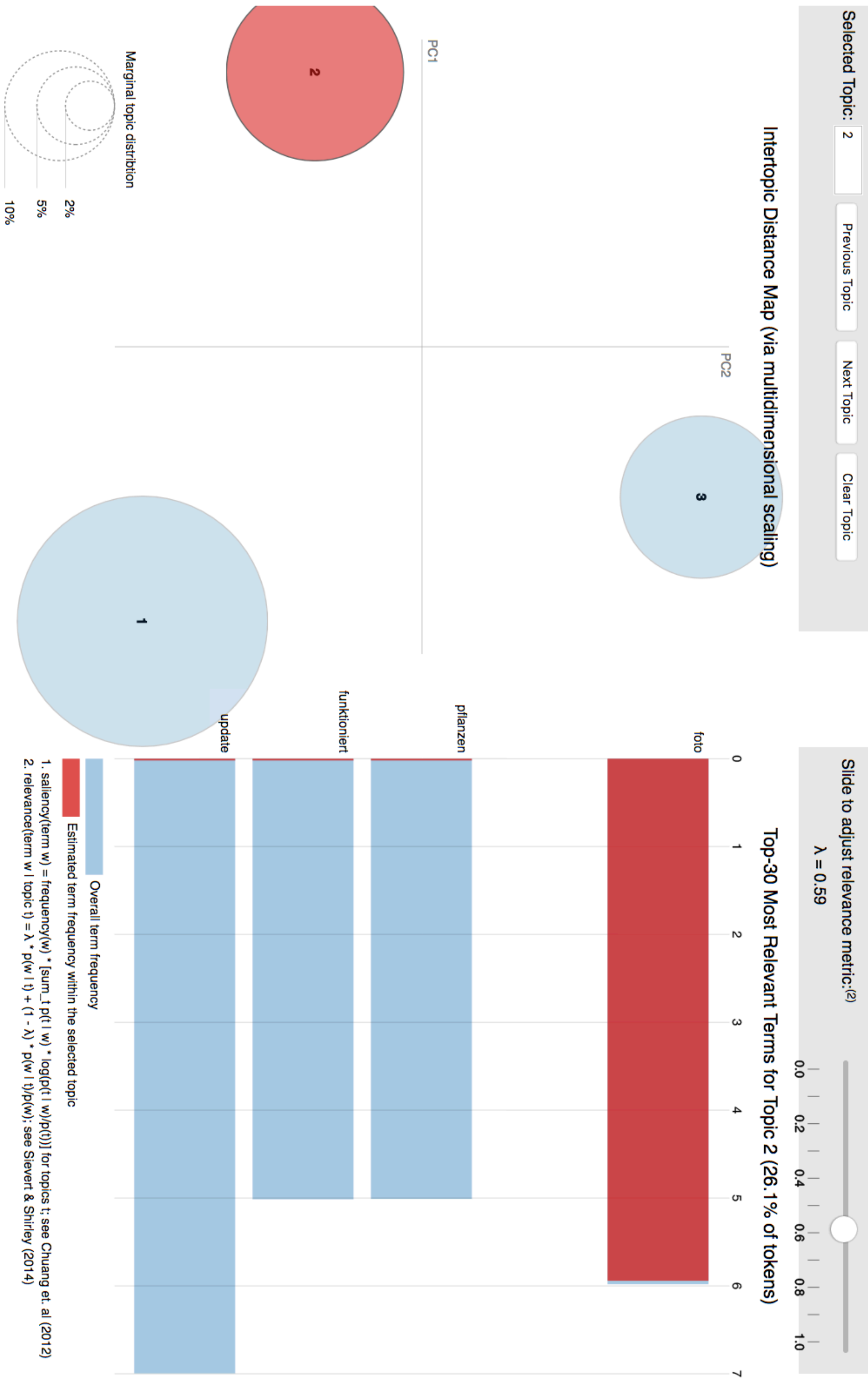


Size of the topics for the positive reviews in German. Most frequent terms for topic 3



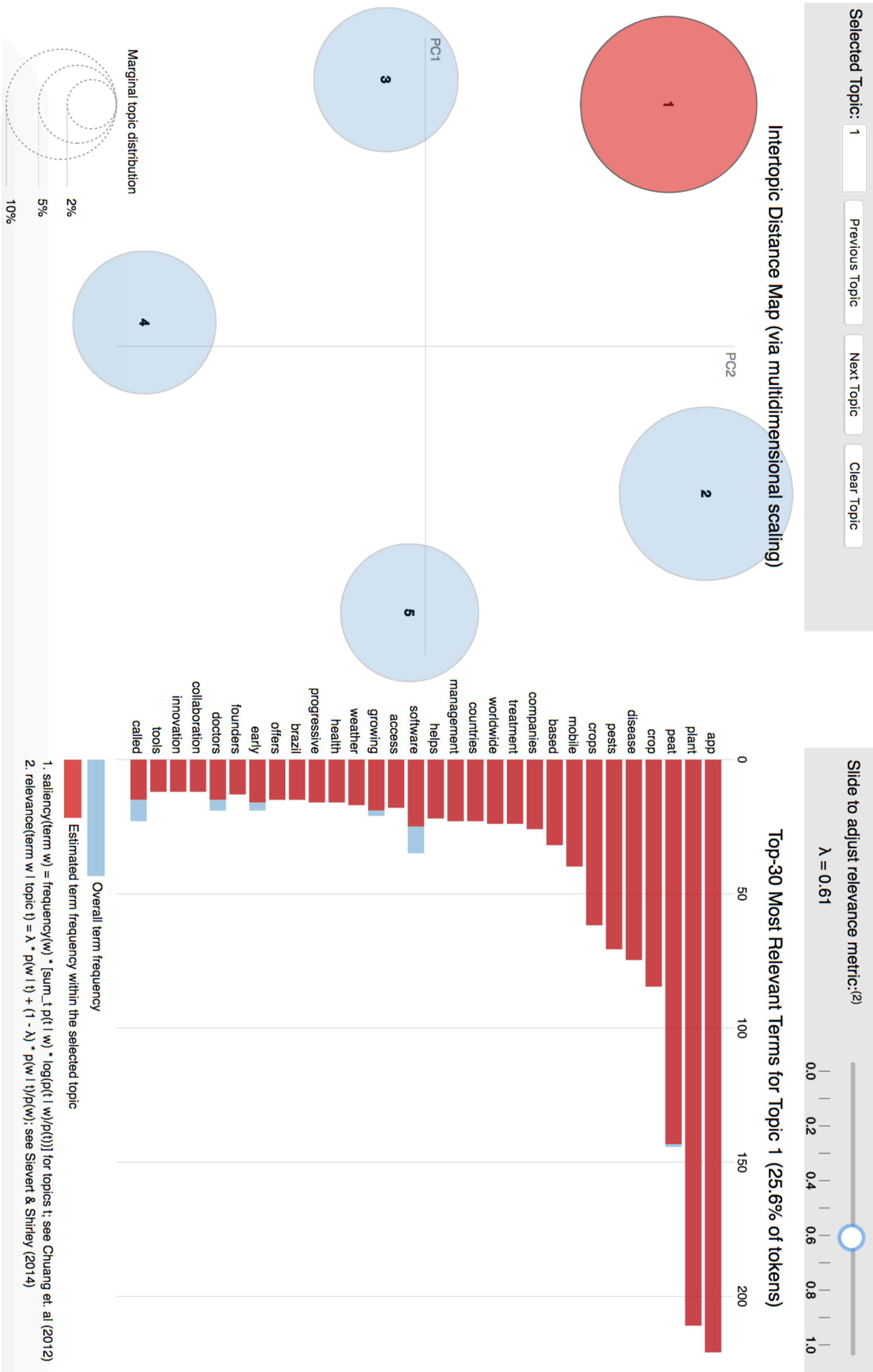
Size of the topics for the negative reviews in German. Most frequent terms for topic 1

Size of the topics for the negative reviews in German. Most frequent terms for topic 2

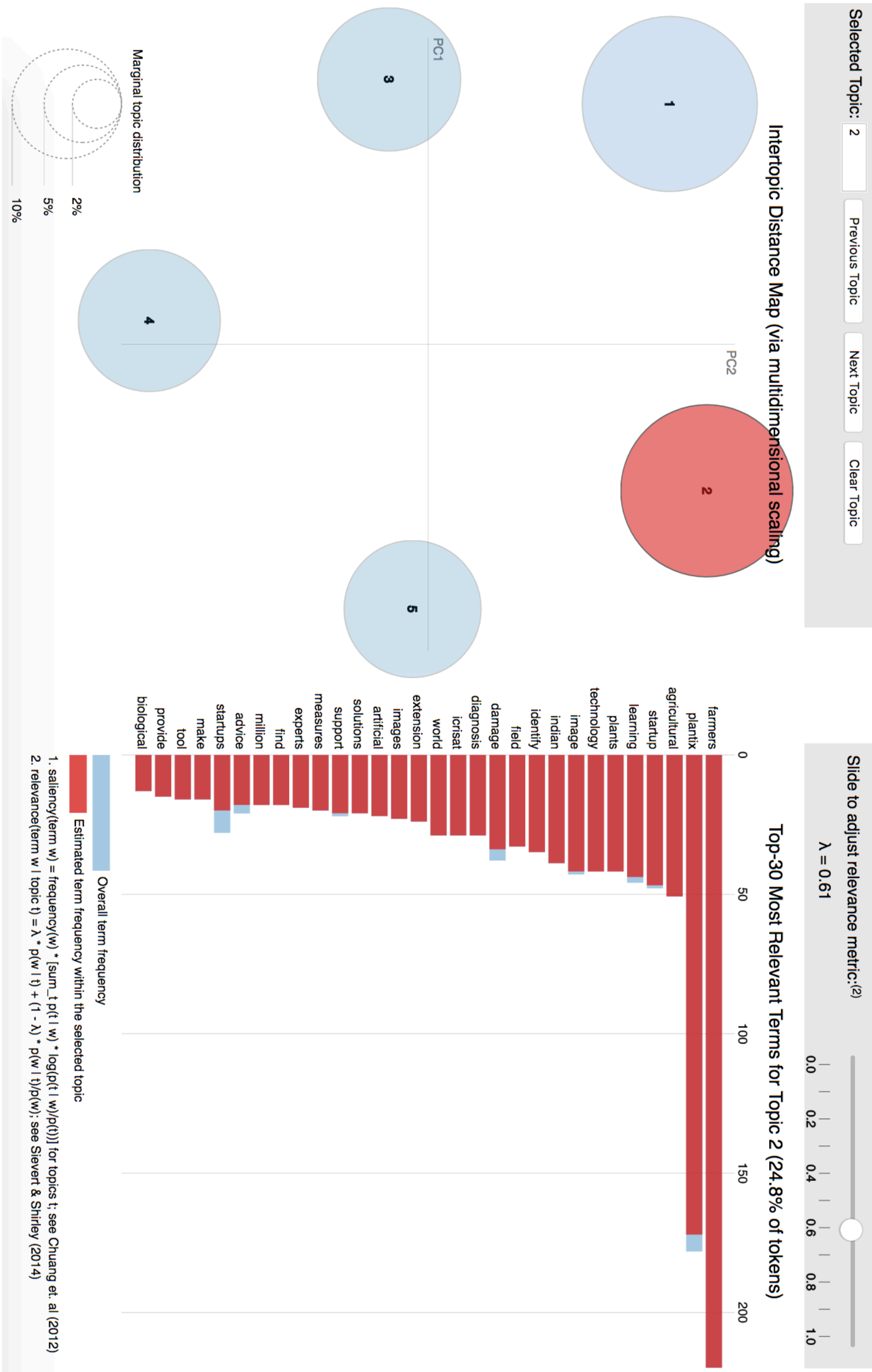


Size of the topics for the negative reviews in German. Most frequent terms for topic 3

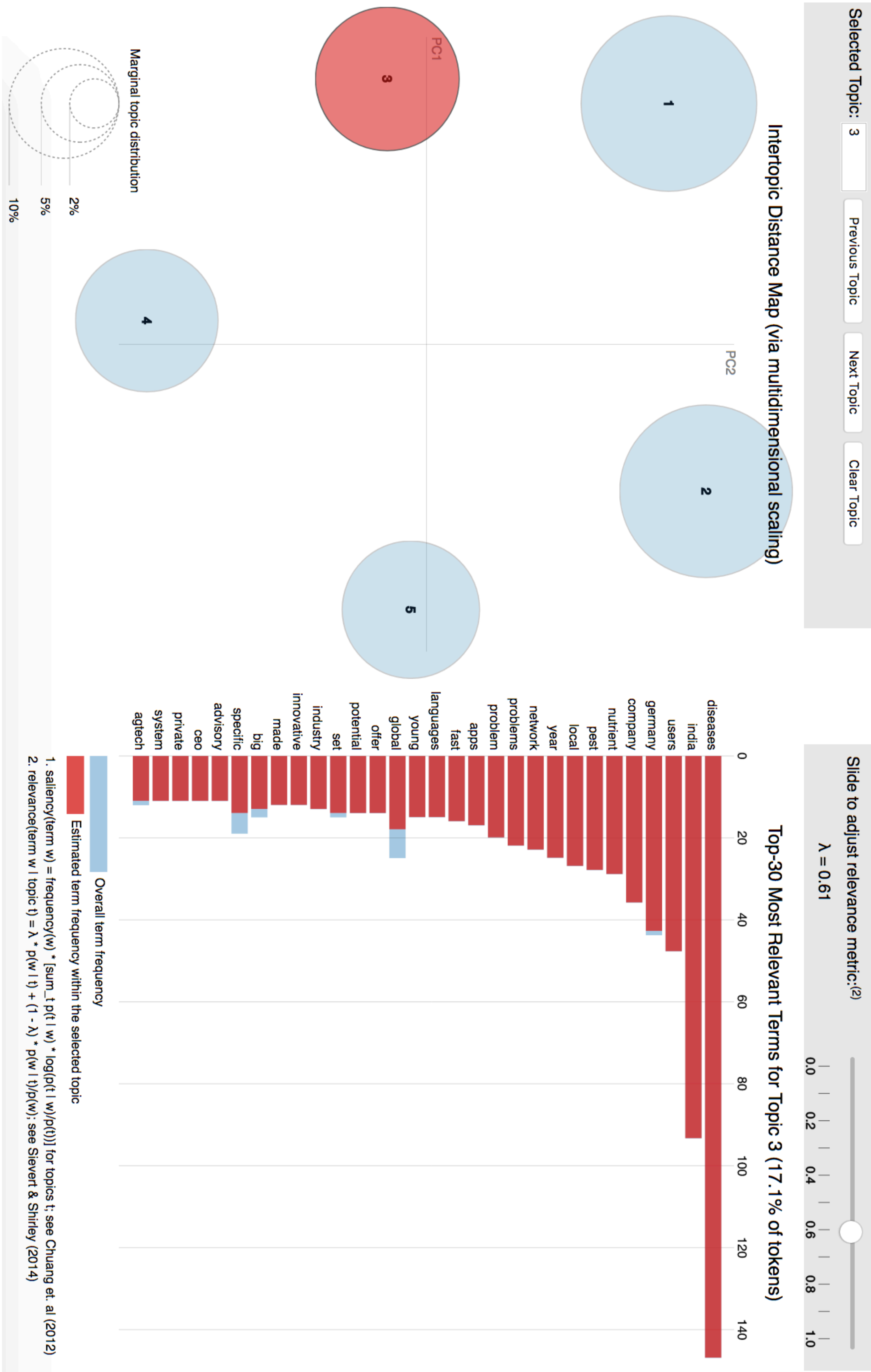
Size of the topics mentioned in the articles in English. Most frequent terms for topic 1



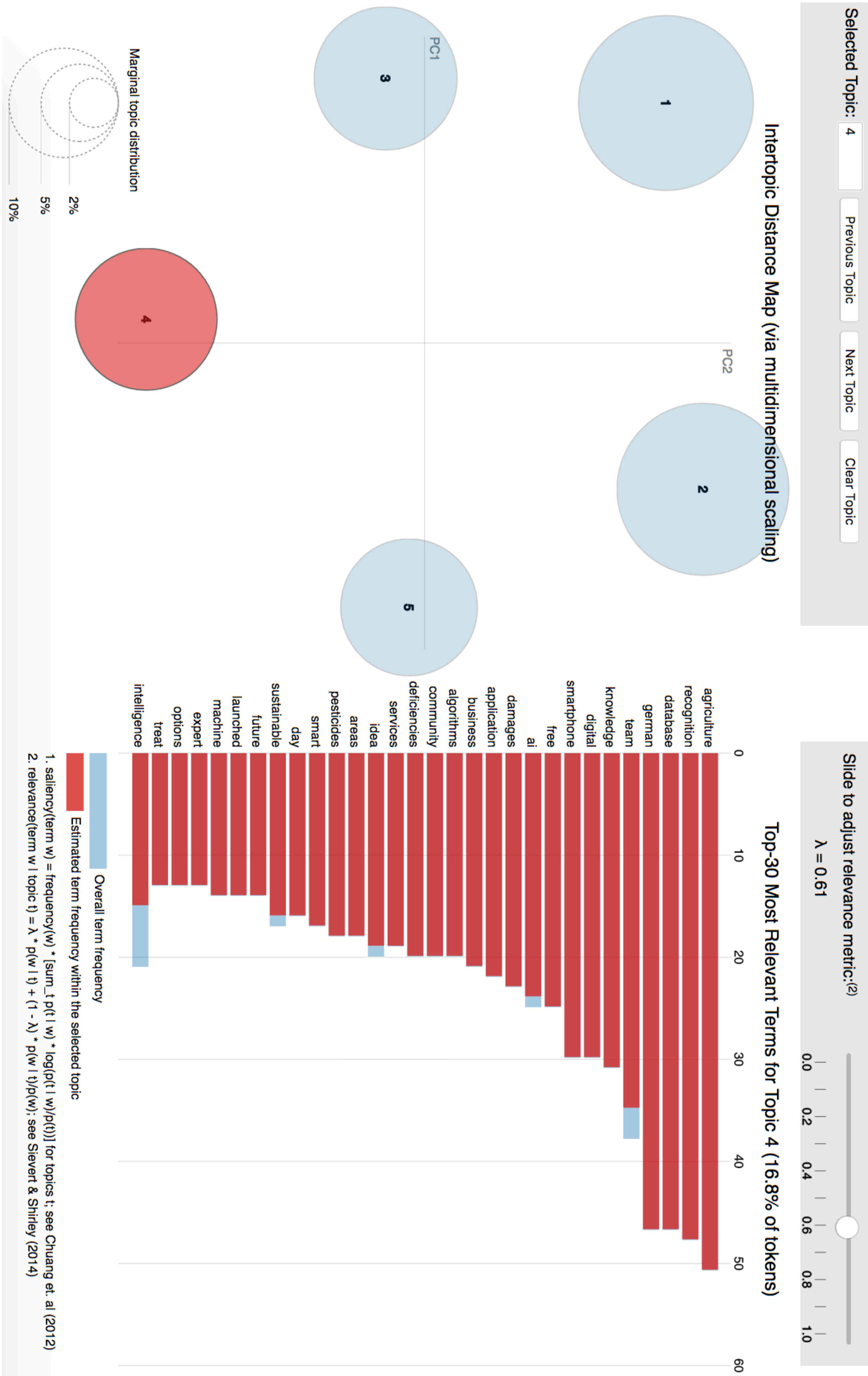
Size of the topics mentioned in the articles in English. Most frequent terms for topic 2



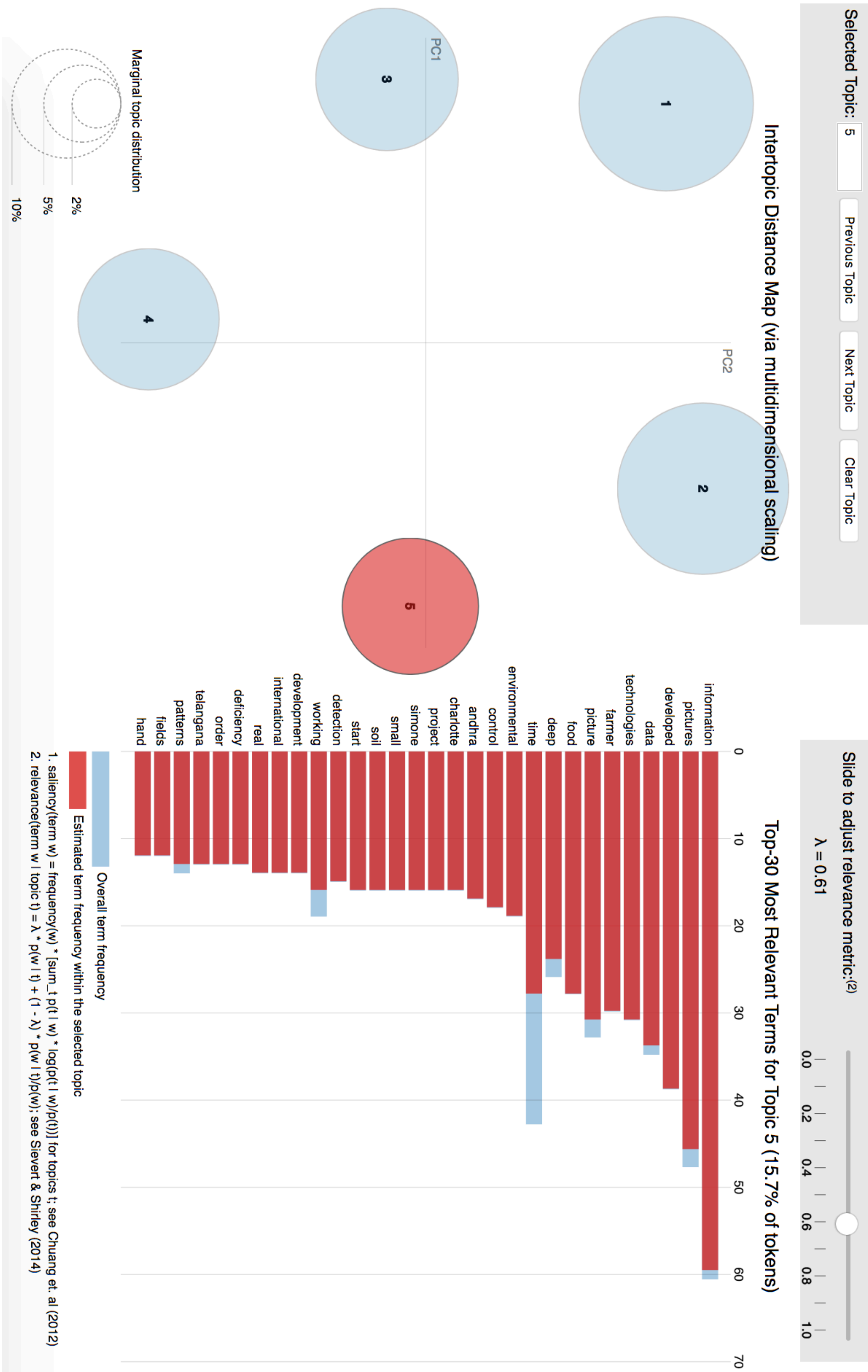
Size of the topics mentioned in the articles in English. Most frequent terms for topic 3



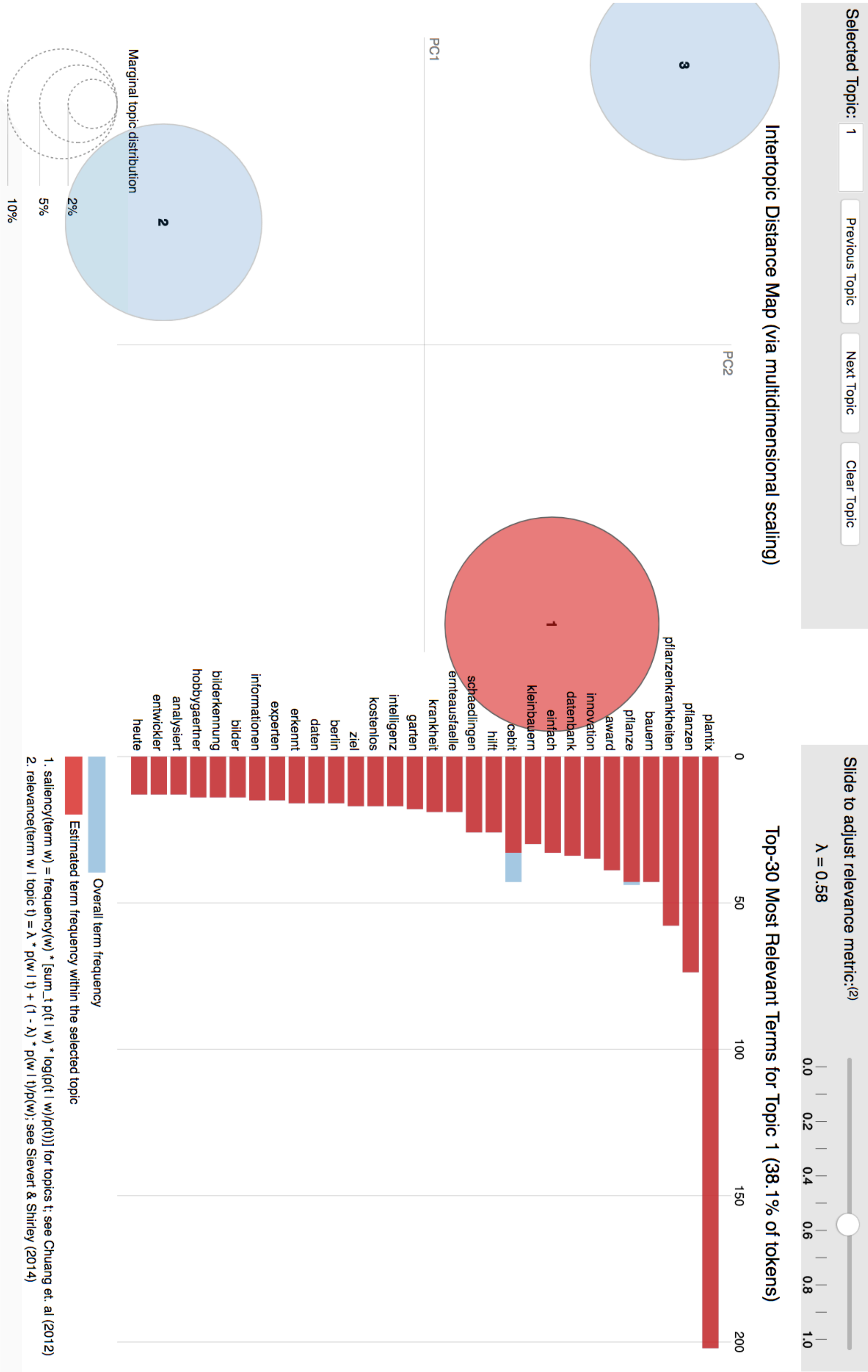
Size of the topics mentioned in the articles in English. Most frequent terms for topic 4



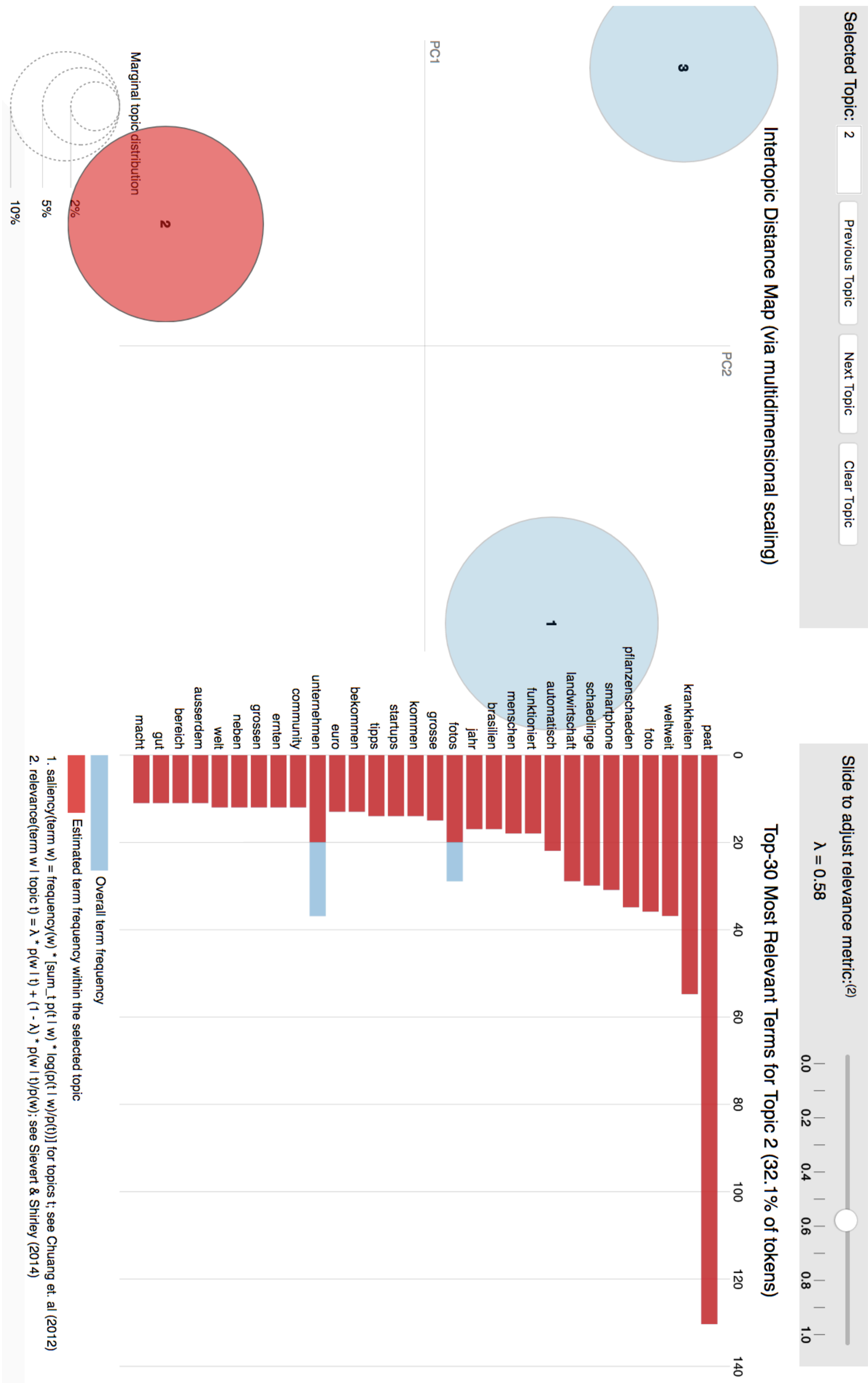
Size of the topics mentioned in the articles in English. Most frequent terms for topic 5



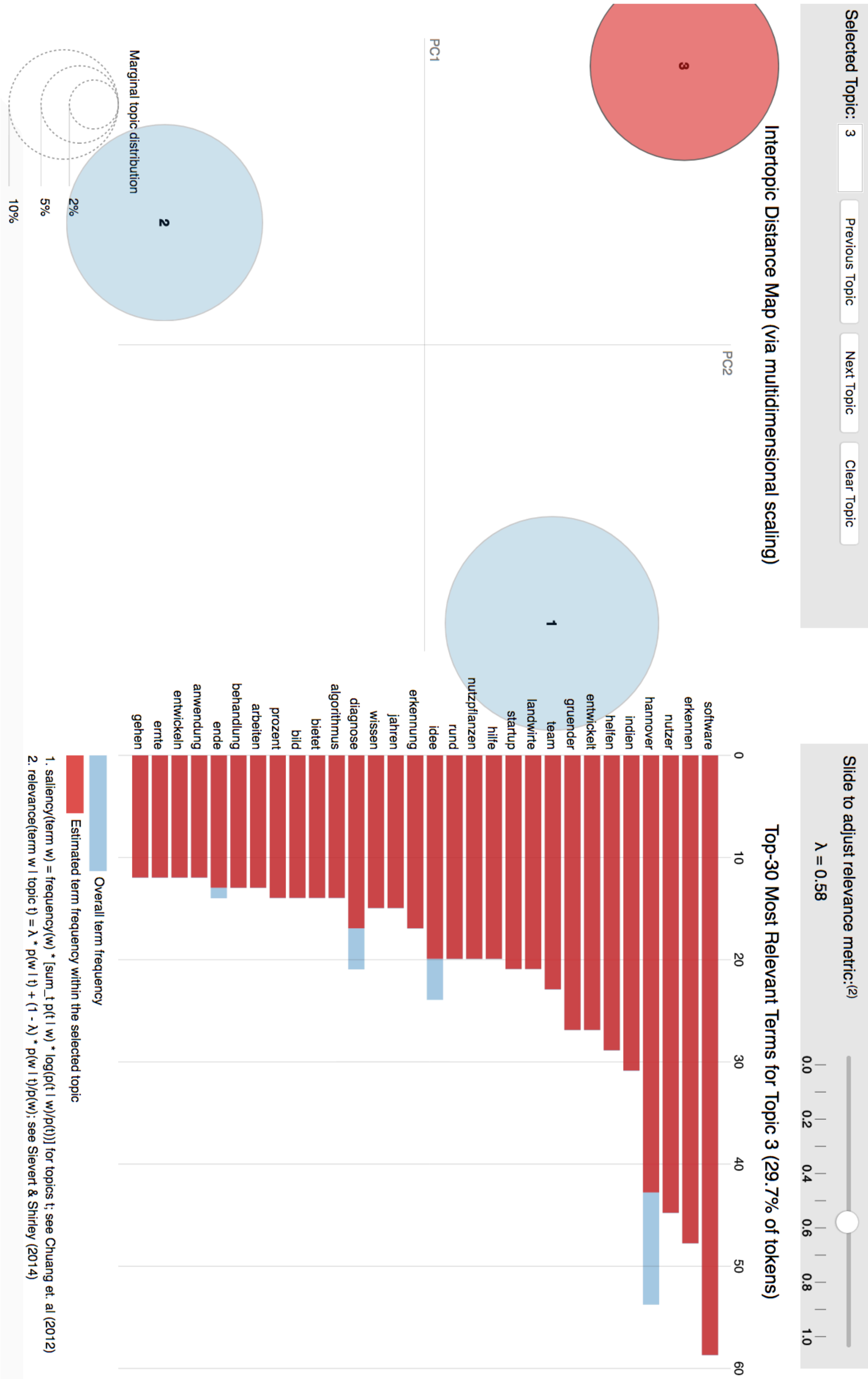
Size of the topics mentioned in the articles in German. Most frequent terms for topic 1



Size of the topics mentioned in the articles in German. Most frequent terms for topic 2



Size of the topics mentioned in the articles in German. Most frequent terms for topic 3



9.6 Articles about PEAT and Plantix app used for LDAvis

Articles about startup PEAT and its app Plantix for topic-modeling in German

1. Bauer, M. (2017): Diese drei Healthcare Startups bewegen die Branche – Healthcare Startups Deutschland. Retrieved from https://healthcare-startups.de/diese-drei-healthcare-startups-bewegen-die-branche/ (06.12.2018)

2. Bayer, M. (2017): Machine Learning und neuronale Netze: Wie Künstliche Intelligenz Arbeit und Gesellschaft verändert. Retrieved from https://www.computerwoche.de/a/wie-kuenstliche-intelligenz-arbeit-und-gesellschaft-veraendert,3329715 (06.12.2018)

3. Cassala, C. (2016): Peat - "Wir helfen, Pflanzenschutzmittel einzusparen". Retrieved from https://www.deutsche-startups.de/2016/08/08/peat-wir-helfen-pflanzenschutzmittel-einzusparen/ (06.12.2018)

4. CeBIT Award (2017): Plantix gewinnt CEBIT Innovation Award 2017. Retrieved from https://www.cebitaward.de/de/1-platz-plantix-1760.html (06.12.2018)

5. CS (2017): Algorithmus für den Acker. Retrieved from https://www.wochenblatt.com/landleben/startklar/algorithmus-fuer-den-acker-8839513.html (06.12.2018)

6. Degner, J. (2018): Plantix App diagnostiziert Krankheiten bei Pflanzen. Retrieved from https://www.smartphonepiloten.de/plantix-app-diagnostiziert-krankheiten-bei-pflanzen (06.12.2018)

7. Deutsche Startups (2017): Millionensumme für Pflanzenretter-App. Retrieved from https://www.deutsche-startups.de/2017/04/13/millionensumme-fuer-pflanzenretter-app/ (06.12.2018)

8. Deutschlandfunk Nova (2017): Die App für den Anti-Gärtner. Retrieved from https://www.deutschlandfunknova.de/beitrag/kranke-pflanzen-die-app-fuer-den-anti-gaertner (06.12.2018)

9. Evers, H. (2017): Digitaler Pflanzendoc: Plantix-App hilft mit künstlicher Intelligenz. Retrieved from https://www.computerbild.de/artikel/cb-News-App-Check-Plantix-App-digitaler-Pflanzendoc-18056581.html (06.12.2018)

10. Exist (2017): PEAT GmbH. Retrieved from https://www.exist.de/DE/Campus/Gruendergeist/EXIST-Erfolge/PEAT-GmbH/inhalt.html (06.12.2018)

11. FARMITOO (2018): Interview mit Korbi, Gründer von Peat, ein agtech-Startup, spezialisiert auf Deep Learning. Retrieved from https://mag.farmitoo.com/de/2018/07/25/peat/ (06.12.2018)

12. Garten Haus XXL (2017): Die besten Garten Apps für Hobbygärtner. Retrieved from http://garten.haus-xxl.de/die-besten-garten-apps-fuer-hobbygaertner/ (06.12.2018)

13. GIZ (2018): Nachhaltige Landwirtschaft und ländliche Entwicklung. Retrieved from https://www.giz.de/de/weltweit/22735.html (04.12.2018)

14. Göbel, J. (2018): Hier steckt Künstliche Intelligenz drin. Retrieved from https://www.deutschland.de/de/topic/wirtschaft/kuenstliche-intelligenz-fuenf-starke-startups-aus-deutschland (06.12.2018)

15. Grün Furtner. (2017): Plantix – Die App für Hobbygärtner. Retrieved from https://team-gruen-furtner.de/plantix-die-app-fuer-hobbygaertner/ (06.12.2018)

16. Gründerimpuls (2017): Das Startup PEAT erhält siebenstellige Finanzierung. Retrieved from http://www.gruenderimpuls.de/peat-bekommt-finanzierung/ (04.12.2018)

17. Gründerszene (2017): 3 Tipps, mit denen Startups zu Global Playern werden. Retrieved from https://www.gruenderszene.de/allgemein/weltweit-expandieren-startup-tipps-scale11-2016-6943 (04.12.2018)

18. hannoverimpuls (2017): Das Smartphone, der grüne Daumen. Retrieved from https://www.wirtschaftsfoerderung-hannover.de/hannoverimpuls/Gruendung-und-Entrepreneurship/Gründungsstorys/PEAT (06.12.2018)

19. Hardt, S. (2017): Plantix: Gewinner-App des CeBIT Innovation Award getestet. Retrieved from https://www.netz.de/apps/news/plantix-gewinner-app-des-cebit-innovation-award-getestet (06.12.2018)

20. Huesing, A. (2016): 5 Start-ups, die Bauernhöfe in die Zukunft beamen. Retrieved from https://www.deutsche-startups.de/2016/06/02/5-start-ups-die-bauerhoefe-die-zukunft-beamen/ (06.12.2018)

21. Hüfner, D. (2017): Diese Startups hält die Cebit für besonders innovativ. Retrieved from https://t3n.de/news/cebit-innovation-award-2017-startups-806936/ (06.12.2018)

22. Kerkmann, C. (2017): Start-up-Preis „The Spark": Der Strom der Zukunft. Retrieved from https://www.handelsblatt.com/technik/thespark/start-up-preis-the-spark-der-strom-der-zukunft/20413780.html (06.12.2018)

23. Kugoth, J. (2017): Der neuste Hype: Ein Algorithmus im Blumenbeet. Retrieved from https://ngin-food.com/artikel/tech-meetup-infarm-peat-green-city-solutions/ (06.12.2018)

24. Leibniz Universität Hannover (2017): Aus der Forschung in die Praxis: Plantix gewinnt den CeBIT Innovation Award 2017. Retrieved from https://www.uni-hannover.de/de/universitaet/aktuelles/online-aktuell/details/news/aus-der-forschung-in-die-praxis-plantix-gewinnt-den-cebit-innovation-award-2017/ (06.12.2018)

25. Lindow-Zechmeister, S. (2017): Plantix – Der Pflanzendoktor. Retrieved from https://www.android-user.de/plantix-der-pflanzendoktor/ (06.12.2018)

26. Mainzer, S. (2017): CeBIT 2017: Der grüne Daumen gewinnt. Retrieved from https://digitaler-mittelstand.de/trends/ratgeber/cebit-2017-der-gruene-daumen-gewinnt-33589 (06.12.2018)

27. Medicus, M. (2017): Pflanzen-App Plantix gewinnt CeBIT Innovation Award 2017. Retrieved from https://www.connect.de/news/cebit-innovation-award-2017-plantix-app-3196983.html (06.12.2018)

28. Meineck, S. (2017): Download-Tipps: Das sind die spannendsten Apps des Mai - SPIEGEL ONLINE - Netzwelt. Retrieved from http://www.spiegel.de/netzwelt/apps/die-besten-apps-des-mai-goat-simulator-plantix-timbre-a-1149866.html (06.12.2018)

29. Mel (2017): Plantix-App erkennt Krankheiten und Schäden an Pflanzen automatisch. Retrieved from https://www.kistengruen.de/wp/2016/08/plantix/ (06.12.2018)

30. Meyer, T. (2016): CeBIT Preview: Plantix-App erkennt Pflanzenschäden. Retrieved from https://www.tariftip.de/News/47581/Plantix.html (06.12.2018)

31. Moßner, J. (2017): 15 spannende Startups aus dem Bereich Digital Farming. Retrieved from https://www.industry-of-things.de/15-spannende-startups-aus-dem-bereich-digital-farming-a-646283/ (06.12.2018)

32. PEAT (2018): Mediakit. Retrieved from http://peat.technology/press-reviews/ (06.12.2018)

33. Raketenstart (2017): Smartphone-App Plantix erkennt und diagnostiziert kranke Pflanzen. Retrieved from https://raketenstart.org/rh2017-app-plantix-erkennt-kranke-pflanzen/ (06.12.2018)

34. Regelein, G. (2017): Schädlingsdiagnose per Smartphone. Retrieved from https://www.sueddeutsche.de/muenchen/freising/start-up-unternehmen-schaedlingsdiagnose-per-smartphone-1.3593431 (06.12.2018)

35. Roland (2017): Plantix - Mit einem Foto zur Ursache. Retrieved from http://agrarbetrieb.com/plantix-landwirtschaft-app/ (06.12.2018)

36. Schonschek, C. (n.d.): CeBIT Innovation Award 2017: Siegreiche Pflanzendoktor App Plantix. Retrieved from https://www.ulmer.de/Siegreiche-Pflanzendoktor-App-Plantix,QUlEPTU0MTE2MTkmTUlEPTg2MDU1.html (06.12.2018)

37. Schulze Stumoenhorst, C. (2018): Algorithmus für den Acker. Retrieved from https://f3.de/algorithmus-fuer-den-acker/ (06.12.2018)

38. Seifert, R. (2017): Ausgezeichnetes Unternehmen PEAT mit App für den Pflanzenschutz. Retrieved from https://breitbandbuero.de/ausgezeichnetes-unternehmen-peat-mit-app-fuer-den-pflanzenschutz/ (06.12.2018)

39. Siering, H. (2016): Plantix - Pflanzendoktor und Erntegefahr-Frühwarnsystem in einem. Retrieved from https://reset.org/blog/plantix-pflanzendoktor-06062016 (06.12.2018)

40. Stanek, S. (2016): Plantix: Fotografieren gegen Schädlinge und Krankheiten. Retrieved from https://www.egarden.de/gartengestaltung/beet/news/plantix-app-248681.html (06.12.2018)

41. Start-Green (n.d.): PEAT. Retrieved from https://start-green.net/netzwerk/gruenes-startup/peat/ (06.12.2018)

42. Startup NDS (2017): PEAT gewinnt Deutschen Digitalpreis "The Spark". Retrieved from https://startup.nds.de/peat-gewinnt-deutschen-digitalpreis-the-spark/ (06.12.2018)

43. Visser, C. (2016): Internationalisierung: Es müssen nicht immer die USA sein. Retrieved from https://berlinvalley.com/internationalisierung-2/ (06.12.2018)

44. Wadhawan, J. (2017): Start-ups in Indien: Mit den vorhandenen Mitteln die bestmögliche Lösung erreichen › absatzwirtschaft. Retrieved from http://www.absatzwirtschaft.de/die-jugaad-revolution-der-indischen-start-ups-mit-vorhandenen-mitteln-die-bestmoegliche-loesung-erreichen-105699/ (06.12.2018)

45. Wikipedia (2018): Plantix. Retrieved from https://de.wikipedia.org/wiki/Plantix (06.12.2018)

46. Wilhelm, C. (2016): Neu auf dem Smartphone - Mit der App gegen Schädlinge. Retrieved from https://www.deutschlandfunkkultur.de/neu-auf-dem-smartphone-mit-der-app-gegen-schaedlinge.976.de.html?dram:article_id=364506 (06.12.2018)

47. Will, S. (2017): Smartphone-App Plantix gewinnt den Innovation Award 2017! Retrieved from https://www.berliner-sonntagsblatt.de/Smartphone-App-Plantix-gewinnt-den-Innovation-Award-2017--98856.html (06.12.2018)

48. WIRED (2017): Die App Plantix erkennt kranke Pflanzen. Retrieved from https://www.wired.de/collection/tech/peat-pflanzen-plantix-app-gruen-schaedlinge-landwirte (06.12.2018)

49. Wittlich, H. (2017): Pflanzenbestimmung per App. Retrieved from https://digitalpresent.tagesspiegel.de/pflanzenbestimmung-per-app (06.12.2018)

50. WIWO (2017): Peat: Digitaler Pflanzendoktor punktet auf der Cebit. Retrieved from http://gruender.wiwo.de/peat-digitaler-pflanzendoktor-punktet-auf-cebit/ (04.12.2018)

51. WIWO (2018): Peat: „Wir heilen Pflanzen auf der ganzen Welt". Retrieved from http://gruender.wiwo.de/peat-wir-heilen-pflanzen-auf-der-ganzen-welt/ (06.12.2018)

52. Wölbert, C. (2018). Hannovers erfolgreichstes Start-up verlässt die Stadt. Retrieved from http://www.haz.de/Nachrichten/Wirtschaft/Niedersachsen/Start-Up-Peat-aus-Hannover-geht-nach-Berlin (04.12.2018)

53. Zahn, S. (2017): Experteninterviw mit PEAT über ihre Pflanzendoc App Plantix. Retrieved from https://www.energieheld.de/blog/experteninterview-plantix-pflanzendoc-app/ (06.12.2018)

Articles about startup PEAT and its app Plantix for topic-modeling in English

1. Agus, S., Vanian, J. (2017): 6 'Change the World' Companies That Are Rising Stars. Retrieved from http://fortune.com/2017/09/07/change-the-world-ones-to-watch/ (06.12.2018)

2. Best Apps Guru (2018): Top 5 Best plant identification app (2018). Retrieved from http://bestappsguru.com/best-plant-identification-app/ (06.12.2018)

3. CABI (2018): CABI trials PEAT's smartphone app Plantix that identifies plant pests in the field. Retrieved from https://www.cabi.org/news-and-media/2018/cabi-trials-peats-smartphone-app-plantix-that-identifies-plant-pests-in-the-field/ (04.12.2018)

4. CoFounder (2017): PEAT Progressive Environmental & Agricultural Technologies. Retrieved from https://dea.digar.ee/cgi-bin/dea?a=d&d=AKcofounder201702.2.26.1 (06.12.2018)

5. Crunchbase (2016): PEAT GmbH // Plantix App. Retrieved from https://www.crunchbase.com/organization/peat#section-overview (06.12.2018)

6. Datadrivenfarming (2017): SOLUTION: Peat – a mobile crop diagnostic application for farmers worldwide Finalist. Retrieved from https://datadrivenfarming.challenges.org/selected/20/-peat/ (06.12.2018)

7. Deutsche Welle (2017): The fungus-fighting plant app. Retrieved from https://www.dw.com/en/the-fungus-fighting-plant-app/a-38575892 (06.12.2018)

8. Development Channel (2017): App to help farmers identify plant diseases launched. Retrieved from http://www.developmentchannel.org/2017/07/23/app-to-help-farmers-identify-plant-diseases-launched/ (06.12.2018)

9. Dias, C. (2016): German Startup PEAT's Plant Disease App Is Empowering Indian Farmers. Retrieved from http://www.networkedindia.com/2016/10/11/german-startup-peats-plant-disease-app-empowering-indian-farmers/ (04.12.2018)

10. DigitalFoodLab (n.d.): Plantix The security of your harvest in your hands! Retrieved from https://www.digitalfoodlab.com/en/foodtech-database/plantix (06.12.2018)

11. Elsässer, S. (2017): 3 health startups against the great problems of our time. Retrieved from https://www.startupvalley.news/uk/digital-health-how-startups-are-changing-the-healthcare-industry/ (04.12.2018)

12. Euronews (2017): The plant doctor app helping to identify plant disease. Retrieved from https://www.euronews.com/2017/01/04/the-plant-doctor-app-helping-to-identify-plant-disease (06.12.2018)

13. FAO (2017): Plantix: The app to detect and cure your plant diseases. Retrieved from http://www.fao.org/e-agriculture/news/plantix-app-detect-and-cure-your-plant-diseases (06.12.2018)

14. Fernandes, V. (2016): Self-learning algos could help farmers diagnose plant diseases and damages instantaneously. Retrieved from https://yourstory.com/2016/09/plantix-agriculture-india/ (04.12.2018)

15. Genderingermandevelopment (2017): Women Plant Doctors 2.0 - Competition „Empowerment of women through digital solutions“. Retrieved from https://www.genderingermandevelopment.net/tunisia.html (06.12.2018)

16. Ghavri, S. (2018): The Smart Crop Assistant Powered By Artificial Intelligece. Retrieved from https://www.code-brew.com/blog/2018/06/14/the-smart-crop-assistant-plantix/ (06.12.2018)

17. Giacomo, A. D. (2018): Why It's The Right Time For Indian And German Startups To Collaborate. Retrieved from https://www.huffingtonpost.in/angela-de-giacomo/why-it-s-the-right-time-for-indian-and-german-startups-to-collab_a_22128033/ (06.12.2018)

18. Grzywa, P. (2017): AI for plant diseases [#CEBiT inspiration]. Retrieved from http://ideahub.eu/business/ai-for-plant-diseases-cebit-inspiration/ (04.12.2018)

19. Hindy, J. (2018): 10 best plant apps and flower identification apps for Android. Retrieved from https://www.androidauthority.com/best-plant-apps-flower-identification-apps-android-806167/ (06.12.2018)

20. Houben, S. (2017): PEAT - Mobile crop advisory app. Retrieved from http://www.wunderding.co/peat-mobile-app/ (04.12.2018)

21. ICRISAT (2017): Mobile App to Help Farmers Overcome Crop Damage. Retrieved from https://www.icrisat.org/mobile-app-to-help-farmers-overcome-crop-damage/ (04.12.2018)

22. ICRISAT (2016): Mobile app for pest and disease management of crops. Retrieved from https://www.icrisat.org/mobile-app-for-pest-and-disease-management-of-crops/ (04.12.2018)

23. IndiaAgroNet. (n.d.): Agriculture App Plantix For Farmers by PEAT. Retrieved from http://www.indiaagronet.com/Agriculture-Apps/Agriculture-App-Plantix-by-PEAT.html (04.12.2018)

24. Kontzer, T. (2016): German Startup PEAT's Plant Disease App Is Empowering Indian Farmers. Retrieved from http://www.networkedindia.com/2016/10/11/german-startup-peats-plant-disease-app-empowering-indian-farmers/ (04.12.2018)

25. Korbi (2017): Plantix - grow smart Fighting plant pests, diseases and nutrient deficiencies with a smartphone and the force of human and neural networks! Retrieved from https://network.changemakers.com/challenge/creatingsharedvalue/entry/plantix-grow-smart-with-intelligent-networks (06.12.2018)

26. Krishna, V. (2017): How this German startup is going all out to help the Indian farmer. Retrieved from https://yourstory.com/2017/02/peat/ (04.12.2018)

27. Lasania, Y. Y. (2017): New mobile app for farmers to identify crop damage. Retrieved from https://www.livemint.com/Politics/fbmSthsTdL5TxJ6pB9oFCK/New-mobile-app-for-farmers-to-identify-crop-damage.html (04.12.2018)

28. Madslien, J. (2017): Tell me phone, what's destroying my crops? Retrieved from https://www.bbc.com/news/business-41580890 (06.12.2018)

29. Merck Innovation Center (2017): PEAT: Expanding Our Business with Ten New Talents. Retrieved from https://innovationcenter.merckgroup.com/news-events/all-news/detail/59-peat-expanding-our-business-with-ten-new-talents/ (04.12.2018)

30. Miles, G. (2017): Introducing the Plantix plant doctor app. Retrieved from https://www.farmersweekly.co.za/opinion/blog/greg-miles-digital-farmer/introducing-plantix-plant-doctor-app/ (06.12.2018)

31. Miśta, W. (2017): Interesting German startups you should definitely check out! Retrieved from https://naturaily.com/blog/interesting-german-startups (04.12.2018)

32. Nanalyze (2017): 9 AgTech Startups Using AI to Grow Smarter. Retrieved from https://www.nanalyze.com/2017/09/9-agtech-startups-artificial-intelligence/ (04.12.2018)

33. Rupavatharam, S., Kennepoh, A., Kummer, B., Parimi, V. (2018): Automated plant disease diagnosis using innovative android App (Plantix) for farmers in Indian state of Andhra Pradesh. Retrieved from https://apsnet.confex.com/apsnet/ICPP2018/meetingapp.cgi/Paper/8376 (06.12.2018)

34. Rural & Marketing (2016): PLANTIX APP Detecting plant disease and recommending treatment. Retrieved from https://www.pressreader.com/india/rural-marketing/20161012/282432758670931 (04.12.2018)

35. Sandle, T. (2017): Plantix, the app that helps farmers spot disease. Retrieved from http://www.digitaljournal.com/tech-and-science/technology/plantix-the-app-that-helps-farmers-spot-disease/article/505091 (06.12.2018)

36. Schiller, B. (2017): Machine Learning Helps Small Farmers Identify Plant Pests And Diseases. Retrieved from https://www.fastcompany.com/40468146/machine-learning-helps-small-farmers-identify-plant-pests-and-diseases (06.12.2018)

37. Sennaar, K. (2017): AI in Agriculture - Present Applications and Impact | Emerj - Artificial Intelligence Companies, Insights, Research. Retrieved from https://emerj.com/ai-sector-overviews/ai-agriculture-present-applications-impact/ (04.12.2018)

38. Smart Farmer Digital (n.d.): Now your cell helps you identify those plant diseases and pests. Retrieved from https://smartfarmerkenya.com/now-your-cell-helps-you-identify-those-plant-diseases-and-pests/ (04.12.2018)

39. Staff Writer (2016): Merck brings international start-up-companies to Nairobi & Darmstadt. Retrieved from http://www.itnewsafrica.com/2016/04/merck-brings-international-start-up-companies-to-nairobi-darmstadt/ (04.12.2018)

40. Stanciu, D. (2017): Four Disruptive European Startups/SMEs to Watch out for this Autumn. Retrieved from https://younginnovator.eu/2017/09/4-disruptive-european-startupssmes-to-watch-out-for-this-autumn/ (04.12.2018)

41. Tibbetts, J. H. (2018): Frontiers of Artificial Intelligence: Deep learning brings speed, accuracy to the life sciences. Retrieved from https://academic.oup.com/bioscience/article/68/1/5/4793273 (06.12.2018)

42. Tibbetts, J. H. (2018): From identifying plant pests to picking fruit, AI is reinventing how farmers produce your food. Retrieved from https://www.eco-business.com/news/from-identifying-plant-pests-to-picking-fruit-ai-is-reinventing-how-farmers-produce-your-food/ (06.12.2018)

43. Turk, V. (2017): The hottest startups in Berlin in 2017. Retrieved from https://www.wired.co.uk/article/best-startups-in-berlin-2017 (04.12.2018)

44. Urquijo, J. (2018): Identifying plant diseases with Plantix app. Retrieved from https://www.greenappsandweb.com/en/android-en/crops-plant-diseases-plantix/ (04.12.2018)

45. Welfonder, D. (2017): Startup Stories: Agtech Champion PEAT Tackles Global Food Security. Retrieved from https://agtech.careers/agtech-startup-profile-peat-and-global-food-security/ (06.12.2018)

46. Whatley, M. (2018): Digital transformation revolutionising an industry: Plantix. Retrieved from https://www.bluewren.co.uk/blog/digital-transformation-revolutionising-industry-plantix/ (06.12.2018)

47. Wikipedia (2018): Plantix (mobile app). Retrieved from https://en.wikipedia.org/wiki/Plantix_(mobile_app) (04.12.2018)

48. WSA (2016): Plantix. Retrieved from https://www.worldsummitawards.org/winner/plantix/ (04.12.2018)

9.7 Curriculum Vitae

Personal information

NAME	Anna Iversen (geb. Gubanova)
ADDRESS	Egestorffstr. 18, 30449 Hannover
TEL	+49 163 1917275
EMAIL	anna.gubanova@stud.uni-goettingen.de
DATE OF BIRTH	15 June 1988

Working experience

October 2018 - present

EMPLOYER FuturX GmbH

POSITION Expert in prototyping and innovation management

TASKS
- Project management
- Planing and organisation of the workshops
- Development of the use cases and prototypes

May 2017 - present

EMPLOYER Startwhiff UG

POSITION Founder of the online marketplace FANCIQ

TASKS
- Development of the business models
- Business administration

June 2014 -May 2019

EMPLOYER University of Applied Arts and Science Hannover

POSITION Scientific assistant

TASKS
- Lecturing entrepreneurship and e-business
- Research in the area of entrepreneurship and agricultural startups

April 2013 - June 2013

EMPLOYER Hannoverimpuls GmbH

POSITION Intern

TASKS
- Support during the development of the stuff check
- Processing the projects for the technology transfer

January 2012 - April 2012

EMPLOYER United Nations Economic Commission for Europe

POSITION Project assistant

TASKS Research about the possibilities of the biomass use in the regions of Russia

October 2011 - January 2011

EMPLOYER EU Parliament

POSITION Intern to deputy from Saxony

TASKS
- Research and analysis of the cooperation possibilities for technology and innovation transfer between the German federal state of Saxony and Russia
- Preparation of reports concerning diverse sessions in the EU Parliament to be presented to the deputy for his records and presentations

Education

October 2014 - present

Doctorate

INSTITUTION University of Göttingen

October 2010 - September 2013

Master of Science in European Economic Integration / Central and Eastern Europe

INSTITUTION Leipzig University

September 2009 - July 2010

Diploma

INSTITUTION Plekhanov Russian University of Economics

September 2005 -June 2009

Bachelor of Economics

INSTITUTION Plekhanov Russian University of Economics

September 1995 - June 2005

INSTITUTION Public school 1636 (Moscow, Russia)