The Adoption of Legumes in Farmer and Consumer Settings

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Introduction

Agricultural Sustainability, a lasting and productive food supply, is not an option for the agricultural sector but a design challenge. Multiple pathways are plausible. A significant contribution can come from optimized cropping patterns. Alternative crop patterns can lower environmental impacts, reduce energy demands and may create a crop supply that supports healthier diets. As will be discussed below, cropping legumes can advance all three of these goals. In western countries, where farmers predominantly supply whatever markets demand, a transformation process to change crop quantities in agri-value chains cannot solely rely on farmers. A perspective on supply and demand is required. A prerequisite for adopting crops is a well understood target group, i.e., farmers and consumers, and a firm grasp of the context that enables the change process (Donner-Banzhoff and Bösner 2012). In consideration of legumes potential, this thesis addresses topics surrounding the adoption of legumes in farmer and consumer settings.

Legumes' case for a sustainable food production

There are several reasons that legumes can contribute to more sustainable food production. One rather unique trait, the ability to attract bacteria that accumulate nitrogen from the air in order to fertilize plants, makes legumes a technical substitution for nitrogen fertilizers. Organic farming already depends on the trait to achieve current yield levels. Planting legumes in proximity to grains reduces the need for the substantial breeding research on nitrogen uptake of cereals. The trait is well known among agricultural practitioners, but its relevance for sustainability might be underestimated without recalling the environmental cost of nitrogen fertilizers.

One significant climate change issue is the emission of the green-house gas (GHG) Nitrous Oxide (N^2O) (Jensen et al. 2012), which is strongly related to overuse of nitrogen fertilizer. Planting legumes can lower N^2O-emission and is expected to reduce GHG emissions by 5 to 7 times per unit area compared with other crops (Stagnari et al. 2017). Direct CO2-emissions are also expected to be lower than for most competing crops. For example, peas have been shown to demand approximately half as much non-renewable energy input per hectare as wheat, while the output gap is smaller, leading to a significantly better energy output/input ratio than winter and summer wheats (Zentner et al. 2004). raw energy surplus despite the current yield disadvantages is grounded in the energy costs of fertilizers. In general, synthetic fertilizers consume roughly a third of the total energy in cropping (Gellings and Parmenter 2016). Older estimations assume 52 % of crop productions' energy demand is attributed to nitrogen fertilizers (Rosen 2000). The share is higher than for tractors, irrigation pumps and other equipment. Significant efficiency increases in fertilizer production are no longer expected (Gellings and Parmenter 2016). Nitrogen demand will remain an energy challenge to agriculture. The bulk of the energy is associated with the production rather than packaging, transportation or application. The production of nitrogen fertilizers requires 9 times the energy consumption of potash or phosphate (Gellings and Parmenter 2016).

Recently, the issue of nitrogen fertilizers has been politically salient. The EU has sued Germany for violation of fertilization regulations. The excessive use of nitrogen fertilizers is expected to pollute groundwater, so that the costs for clean water resources are about to increase (Oelmann et al. 2017). In 2017, Germany further restricted the time frame and the amount of nitrogen in agricultural land use (BMEL 2017). Further restrictions are discussed. Especially farms with a focus on cropping and higher synthetic fertilizer demands may look toward greater cultivation of legumes. Such farms would

additionally benefit from legumes' positive influence on soil structure and soil fertility (Stagnari et al. 2017).

Legumes have been a salient topic with international organizations. The United Nations (UN) General Assembly declared 2016 to be the international "year of pulses". They intended to raise awareness of the health-improving qualities of legumes and their benefits as a major source of protein and as a health-promoting category of foods. Additionally, medical literature provides some support for legume consumption. Legumes provide protection against coronary heart disease, type II diabetes and high blood pressure (Bouchenak and Lamri-Senhadji 2013; Afshin et al. 2014), and help to normalize blood glucose and insulin levels. The health benefits are often linked to the high fibre content (Papanikolaou and Fulgoni, III, Victor L. 2008).

In consideration of legumes' case for sustainable agriculture, the articles, included in the thesis, are dedicated to understanding farmers' and consumers' decision process. The foremost aim of the articles is to help to design strategies for enhanced legume shares in food supply chains.

Legumes in a farm setting – crop mixtures of legumes and cereals

Until the 1990s legumes occupied predominantly over 7.000.000 million hectares of agricultural land in Europe. A steady decline followed, and by 2008 there were only approximately 2.5 million hectares of legumes being cultivated. In 2014, roughly 3.6 million hectares were cropped (FAOSTAT 2017). The decline occurred for multiple reasons. Market prices were low, because quantity flows were not sufficient to create efficient market structures (Specht 2009). Annual return calculations do not always consider legumes' value in crop rotations. Breeding investments and breeding progress have been less significant than with other crops, therefore increasing the economic disadvantage (Specht 2009). Despite economic limitations, agricultural stakeholders have maintained interest. The latest EU common agriculture policy (CAP) reform has also introduced greening obligations that incentivize the cropping of legumes to utilize their benefits for local production systems (BMEL 2015). Additionally, many member states have implemented national protein crop strategies in order to support legumes. As a result, many farmers can afford to crop legumes to satisfy the protein needs of livestock. Others farmers seed legumes within cover crop mixtures (Specht 2009). However, the economic incentives have not been sufficient to predict a bright outlook for legumes in the farm sector. Facilitating the diffusion of legumes may require more efforts at publicizing legumes' advantages that are not sufficiently communicated or farmers are unaware of. Less known approaches to integrating legume cropping offer an additional potential to convince farmers that increasing legume production is worthwhile. In general, farmers should be made aware of all options to crop legumes in order to provide them maximum flexibility in the approaches they can take to increasing legumes' share of the crops they cultivate. Therefore, we (the authors of article 1) discuss a cropping approach that has a lot of potential to reduce dependence on non-renewable resources, while providing plant based proteins and carbohydrates. The approach will, however, need considerable efforts by researchers and agricultural stakeholders to achieve widespread relevance.

Crop mixtures, the growing of two or more coexisting crops in one field, all to be harvested, can increase the share of legumes in agriculture. Legume-cereal mixtures used to be a vital part of European agriculture as pre-industrial agriculture utilised the ecological benefits of such mixtures to optimise the cropping system before chemical fertilisers and pesticides were widely available. Crop mixtures can be utilised in an industrialised approach in the form of alley cropping, a special case of intercropping. The approach can help to diminish global biodiversity losses by promoting

agrodiversity and the associated biodiversity in agricultural ecosystems (Malézieux et al. 2009; Wezel et al. 2014), thereby addressing the growing public concern about biodiversity (Novacek 2008). The mixtures may increase total land productivity relative to pure cereal stands. So far, research has established yield advantages in low input systems (Brooker et al. 2015; Duc et al. 2015). Additionally, pest and disease impacts are reduced due to an increase in competition among pest types (Malézieux et al. 2009; Wezel et al. 2014). The mixtures also benefit from increased water use efficiency and an accompanying resistance to droughts (Wang et al. 2015).

In contrast, there are still obstacles such as adjustments in technical equipment and the adaptation of seed varieties (Malézieux et al. 2009; Wezel et al. 2014). A combine harvester is suited to harvesting grain legumes and cereals, but the yield is a mix of unspecified crop proportions. Selling mixtures will involve additional costs associated with upgrading the post-harvest processing equipment so as to separate the cereals and legumes. Other cropping work flows also vary. Agribusinesses could embrace mixtures and make the needed technological adjustments, and enlarge the innovation potential for the agricultural machinery and seed markets. Seed varieties that perform best in a monoculture system do not necessarily perform well in mixtures, meaning that breeding research and extension services will be required. Certainly, in the past, modern agriculture has successfully adjusted the cropping system to industrial equipment and it is feasible that present-day agriculture will be able to adjust its equipment to other cropping systems.

Nevertheless, farmers are still facing risks. The use of standard agricultural machinery presents technical challenges. Varieties' performance in mixtures is often unknown. The timing of crop maturity needs to be synchronized. Lead users could increase transparency on the challenges and help to enable a diffusion process. In an effort to understand the potential for adoption, we have studied the trial willingness among farm managers to try cereal-legume crop mixtures (article 1). Intentionally, agricultural stakeholders learn more about the degree of farmers' acceptance and what kind of farmer is open to or eager for information. We selected an approach to classify farmers according to whether they rejected, were willing to contemplate or were willing to adopt cereal-legume mixtures. The study allows for well targeted marketing campaigns among farmers and examines adoption tendencies. Essentially, the study (article 1) will introduce the benefits and challenges of crop mixtures to farm managers and present the findings of a telephone survey among them.

Legumes in a consumer market setting – marketing their health and environmental value

The latest data from 2013 have estimated Germany's direct consumption of peas, beans, soybeans and other pulses combines to 1,61 kg/capita/year (4,4 g/capita/day). The averages for Europe (2,75 kg) and the World (8,73 kg) have consistently been higher (FAOSTAT 2017). Conclusively, the interest in legumes In Europe can be described as modest. Environmental researchers have more of an interest in legumes, due to their potential role as climate friendly and nutritious food. For example, life-cycle assessment studies have analyzed legumes' potential to reduce the environmental impact of food consumption if legumes were to replace animal based protein (Harwatt et al. 2017). Less known is legumes' potential to reduce the environmental impact of providing biomass compared to crops such as wheat (Zentner et al. 2004). Despite environmental benefits or good processing qualities (Vaz Patto et al. 2015), legumes are not a common ingredient in processed food nor overly used in European kitchens. A lack of publicity and a lack of modern marketing campaigns have added to a role of importance in the food sector (Schneider 2002). Widespread recognition of the additional value that legumes offer might gain them a seat at the table, i.e., an increased adoption in daily food

As of late a few niche products have been introduced to the market: pea milk, novel branding of pea soup, fava bean meat alternatives, lupine yoghurt, chickpea-chips, lupine bread spread or lupine ice-cream. Legumes used to missed out on innovation in the food processing sector (Schneider 2002). Innovation is known to be valuable in promoting consumption. Marketing's potential to increase legume demand might be better with innovative products whose reputation is still under development and might lead to new applications in human diets. Looking into novel pasta products, we (the authors of article 2) analyzed consumers' interest in having legume-based instead of wheat-based pasta (article 2). The study examines strategies to increase consumption based on legumes' value for healthy diets and environmental-friendliness.

Legumes' nitrogen fixation capacity might be a marketable trait. I have outlined its value for diminishing the eutrophication of water courses by mineral fertilizers (Malézieux et al. 2009), reducing emissions of the greenhouse gas nitrous oxide (Jensen et al. 2012), and preventing carbon dioxide emissions related to fertilizer production. A negative reputation for synthetic fertilizer might increase consumers' demand for legumes. The carbon emission reduction related to the trait might also be a widely comprehensible advantage. The legal framework for health claims allows only for a few general health statements on most legume products. Legumes qualify for health claims based on their rich protein and fibre content. We studied the persuasive power of mineral fertilizer, CO^2-emissions, protein and fibre in the context of health and environmental claims of legumes (article 2). The combination of such claims should have the strongest effect on legumes' perceived value. Health claims provide a rich scientific background to analyse such marketing claims (Pothoulaki and Chryssochoidis 2009). The researched claims should not necessarily be used one to one by food processors, but refined wording may improve validity and impact. Alternative marketing approaches to market legumes' benefits are also plausible, e.g., in the form of information campaigns or labelling strategies. The study (article 2) offers an additional understanding of consumer segments willing to pay more for legume products. Both the identification of effective ways to market legumes' benefits and the knowledge of whom to target can enhance the adoption of the crop.

Excursus 1 and 2 - Facilitating a reduction in nitrogen demand

Multiple pathways can contribute to a food supply less dependent on mineral nitrogen inputs. I present one excursus that can contribute to the agenda. To better market cereals with potential environmental benefits, we (the authors of excursus 1) analyzed rye adoption by pig farmers. Rye is perceived as a crop with low demands on soil quality and nitrogen in order to generate adequate yields. Nitrogen recommendations for rye are about a quarter lower than for wheat (LWK 2012). Animal feeding is the major use of rye, with considerable volatility in comparison to rye demand in human consumption (VDM 2013). Despite demonstrated economic advantages to using rye rather than wheat, it plays a minor role in feeding. In a double-hurdle model, we demonstrate factors that characterize pig farmers who use rye and those who tend to use a considerable amount.

The second excursus deals with genetically modified plants in print media. In my thesis I mention the need for breeding research to advance legumes in crop mixtures, increase yields and reduce flatulence effects. I could also outline the effects of breeding efforts that have dealt with an optimization of nitrogen uptake by major cereal crops. In any case, breeding efforts, executed with modern techniques of some form, are essential to facing the nitrogen challenge. Independent of the breeding technique, new varieties are needed to face climate change and support regions with an underperforming agricultural sector. The public debate around GMOs may not only influence

breeding progress directly, but can also shed light on topics that reinforce a negative reputation of the breeding sector. If breeding companies neglect public concerns on other topics, the wariness on both sides of the debate will remain and complicate progress. Building on a theory of media relationships, I analyzed the overlap of coverage of GMOs with that of intellectual property rights on seeds, biodiversity losses connected to seeds and market concentration in the sector. Some of the issues might be connected to GMO, therefore breeding companies should consider the issues in GMO issue management. A combined approach can help to build a more supportive relationship with the public.

Article 1: The case of legume-cereal crop mixtures in modern agriculture and the transtheoretical model of gradual adoption

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Abstract:

Mixed cropping (MC), the growing of two or more coexisting crops in one field, specifically the mix of cereal and grain legumes, can contribute to a more sustainable agricultural land use. Despite a variety of ecological benefits and promising grain productivity, applications are scarce among farmers in developed countries. In consideration of MC's potential this study interviews farm managers to profile characteristics of adopters. The transtheoretical model (TTM) is applied to capture adoption and adoption tendencies. The results point to a significant positive role of land owned vs. leased, adoption of reduced tillage, and adoption intensity of legumes in general. The perception of technical barriers and the perception of MC's usefulness are also major drivers that proponents need to address. In general, the TTM provides a gradual measure of farmer's willingness to adopt leading to more variance than binary classifications, which makes TTM especially useful to adoption research of marginalized ecological practices.

Keywords*:* intercropping, alley cropping, agro-ecology, conservation agriculture, ecological intensification, innovation adoption

1. Introduction

The Food and Agriculture Organization of the United Nations (FAO) promotes conservation agriculture to reduce dependence on chemical inputs and diminish eutrophication. Conservation agriculture (CA) builds on three principles: the continuous minimum mechanical soil disturbance, the permanent organic soil cover and the diversification of crop species grown in sequences and/or associations (FAO, 2016). The latter, associated crop mixtures, is often considered suitable only for developing country settings with low labor costs. Nevertheless, industrialized and mechanized "mixed cropping" (MC) approaches are available, although rarely connected with CA-methods.

Noteworthy, the term "Mixed Cropping" created confusion outside the plant scientific community. Agriculture economists tend to understand it as a mix of cropping and livestock on a farm. The term "Intercropping" can create an image of agriculture without the opportunity for a mechanized farm management with combine harvesters etc. A less practical but distinctive term may be "industrialized crop mixtures" or "legume-cereal crop mixtures in modern agriculture". So practicing MC i.e. growing two or more main crops in one field simultaneously, can help to design a sustainable agriculture cropping system, because it reduces the need for exhaustible resources. A mixture of grain legumes and cereals has been found to improve the biological pest management (Hauggaard-Nielsen et al., 2008; Malézieux et al., 2009; Hiddink et al., 2010; Pan and Qin, 2014; Wezel et al., 2014; Vrignon-Brenas et al., 2016), reduce synthetic fertilizer needs (Malézieux et al., 2009; Wezel et al., 2014; Vrignon-Brenas et al., 2016) and thereby diminishes risks associated with chemical input use (Thornton, 2000; Malézieux et al., 2009). Politically this advantage will gain in salience. Germany's upcoming reform of synthetic fertilizer use will tighten legislation in favor of alternative fertilization methods (BMEL, 2016). Additionally, such mixtures go hand in hand with an increased water use efficiency (Wang et al., 2015), with less eutrophication of water courses (Malézieux et al., 2009) and a reduced risk of soil erosion (Betencourt et al., 2012). The output productivity of mixtures, in terms of grain production per acre, is higher than in mono stands, although research is only conclusive on mixtures vs. mono stand in low input agricultural systems (Brooker et al., 2015; Duc et al., 2015). The enhanced field diversity and the enhanced associated biodiversity (Malézieux et al., 2009) can satisfy public demands respectively and present a path to reduce mono-cropping in modern agriculture.

On the contrary, MC imposes new technical obstacles and lacks knowledge relevant to ensure an efficient implementation, so that MC is still poorly integrated with agriculture (Wezel et al., 2014). Mixtures require the coordination of the maturity of two or more crops, a novel variety selection and a diversified depth in seed drilling. Farmers also face technical hurdles, as they need to separate the MC harvest crops in order to fully utilize their value. The sieving process of MC-crops is not part of the farmer's standard workflow. On-farm experience with mixtures would increase transparency on the barriers regarding knowledge and technical risks. Such obstacles root deep into the science and technology landscape of agriculture. The breeding of seed varieties, the design of agriculture machineries, the extension services, best practice recommendations, plant protection and more; most agricultural progress evolves around mono stands. For decades incremental innovations have enhanced productivity and efficiency of mono stands. Multi-cropping systems were hardly developed. This research gap creates a technological "lock in" to mono-stands, meaning the path of technological progress is built around a specific system, e.g. mono stands, not because the performance is necessarily better, but it is difficult or costly to escape from this path (Perkins, 2003). Considerable investments would be necessary to optimize production factors of mixtures. Up until now research on mixtures is

rare (Duc et al., 2015), especially socio-economic research. Efforts by agronomists, to analyze the relative MC-advantages, are just beginning to counter the research lock-in.

Research limitations present an economic risk for farmers who switch field management from mono- to multi-cropping systems. Farmers have to deal with all challenges involved. They cannot rely on extensive performance reports of crop varieties or specialized agriculture machinery to reduce the work load. Subsidy payments have not been established. Currently, political support schemes incentivize pure legume cropping for their ecosystem services, e.g. within the greening obligations of the EU's common agriculture policy (CAP), but the MC-fields are treated as just another crop in the farm portfolio (BMEL, 2015). Conclusively, in economic terms, MC needs to compete with the profitability of pure cereal stands and a lack of socio-economic research hinders a concrete and transparent economic assessment. So MC adoption is marginal among farmers. E.g. in Germany the adoption is limited to 88300 ha which accounts for 0.007 % of all land distributed to cropping (AMI, 2014). Compared to 84600 ha in 2011 MC has experienced subtle growth, but from a macro perspective the diffusion process is still in its infancy.

While conservation practices, like conservation tillage, no-tillage, cover crops and others, have become salient in farm adoption research (Knowler and Bradshaw, 2007), adoption research has so far neglected the marginalized MC approach. The identification of early adopters holds considerable value for the diffusion of an innovation (Schreier et al., 2007). Such early adopters can also help to optimize a technology. Farm trials and their MC related needs may contribute to a more efficient implementation in different cropping environments and thereby enrich the research on MC. Additionally, they involve farmers in innovation development processes and encourage participatory processes (Edwards et al., 1993; Pannell et al., 2006). A significant fraction of innovations is directly initiated by the needs and specific requests of users (Lüthje and Herstatt, 2004). The early adopters may foresee new or future needs of the market significantly earlier than the majority (Lüthje and Herstatt, 2004). Possibly MC-advantages can be used to communicate an additional value of farm products to consumers or offer a flexible approach to enhance legume cropping to comply with stricter regulations on synthetic fertilizer use or soy imports. The profile of early adopters is also valuable to agribusinesses that provide products or extension services related to MC. If the adopter profile underlies a trend to expand or diminish, then such profile information provides some outlook on the potential of MC's diffusion.

Typically, agricultural research uses nominal classifications for adoption (Knowler and Bradshaw, 2007). In the case of MC, recalling the technological and economical challenges, adoption levels are comprehensible low. Binary classifications do not capture the willingness to adopt a multi-cropping system, but only reflect the current farmer's opinion on the best choice for the farm. We propose the transtheoretical model (TTM), which can account for gradual adoption tendencies. TTM is designed to analyze the progress of an individual in changing a specific behavior (Prochaska and Velicer, 1997). The multiple adoption stages enlarge the statistical variance, valuable to marginalized innovations that could otherwise not be modelled.

We expect attitudes towards MC and perceptions of technical barriers will differ significantly along the stages of the adoption process. Further we hypothesize that crop management, farm and farm manager's characteristics vary significantly from adopters to non-adopters. The selected characteristics are common to CA-adoption research. Such properties guide an identification of early adopters. An empirically study of farmers is used to test these assumptions and bring out relevant properties. Hence, we interviewed via telephone a sample, geographically representative in Germany, and analyzed it with the means of a proportional odds model. The limitations of the research design are directly stated

in the context of the results. The findings are discussed with CA-adoption literature. Conclusions follow.

2. Materials and Methods

2.1 Survey Design

2.1.1 The Transtheoretical model and Mixed Cropping adoption

In consideration of the technological lock-in to monocrops, that we have discussed, we need to recognize the perceived change that a mixed cropping system imposes on farmers. MC cannot be added to mono stands, but is a technology competing for adoption. Adoption models have considered the relative advantage of one technology over alternatives among other drivers (Rogers, 2010). The transtheoretical model (TTM) for behavioral change is even more concerned with the rethinking of the current behavior (Prochaska and Velicer, 1997). Although TTM was designed to track personal changes of deeply rooted behavior related to health choices, like smoking, rather than agricultural matters, TTM has also been useful to analyze a psychological change with respect to environmental behavior (Tobler et al., 2011). In similar fashion TTM can analyze farmer's intention to change an established behavior and switch from mono-cropping to mixed cropping. The model provides additional insights into the gradual stage of change that can be interpreted as adoption tendencies. The feature is especially useful to analyze practices where final adoption is rare, so that minimal variance of the adoption parameter could otherwise endanger a meaningful statistical analysis.

The stages of the TTM capture the gradual attitude from rejecting a behavioral change to adopting it. TTM verbalizes the outcome of each individual evaluation of the pros and cons of changing, so a farmer chooses a stage based on what is most appropriate to describe his/her stage of adoption. The four stages can be summarized and have been operationalized similar to Tobler et al.'s (2011) application in the food sector (Table 1).

[Table 1 about here]

2.1.2 Farmers' perception of Mixed Cropping

The perception of MC will influence the farmer's acceptance and implementation. Pannell (1999) has outlined awareness and key perceptions that play a role in trialing conservation agriculture practices: (1) the perception that it is feasible to trial the innovation, (2) the perception that the innovation is worth trialing and (3) the perception that the innovation promotes the farmer's objective.

Firstly, MC's trialing feasibility is limited by the farmer's endowment to technically execute the trial. MC involves technical challenges (Wezel et al., 2014), as we have discussed. A need for new equipment increases the risk for farmers (Rodriguez et al., 2009) and requires sufficient financial well-being (Knowler and Bradshaw, 2007). The one-time costs for adjustments will enlarge the stakes involved in the trial. First adoption scales resemble a small scale trial phase (Ghadim et al., 2005). A trial scale bears less risk and spreads awareness and additional management skills among farmers (Ghadim et al., 2005). They reduce barriers as knowledge on effective implementation is developed within each trial setting. However, a critical perception of challenges may also lead to a cognitive barrier to evaluate MC independent of the real costs involved. Therefore, we transformed potential barriers to feasibility into items, namely the perception of adequate labor availability, synchronization of crop maturity and separation of the harvest or the feasibility of direct use of a mixed harvest.

Secondly, whether MC is worth trialing has to be judged from an economic perspective of each individual farmer. Farmers might be reluctant to change, as their current cropping system has ensured the economic continuation of their business. Early adopters of an innovation are found to acknowledge the relative advantage of a practice significantly earlier than later adopters in the diffusion process (Lüthje and Herstatt, 2004; Morrison et al., 2004). The recognition of benefits leads to an improved approval of MC. Thirdly, MC needs to be compatible with the farmer's objectives in cropping. Three different sources of motivations that influence decision making are: (a) gain goals, (b) normative goals and (3) hedonic goals (Lindenberg and Steg, 2007; Etienne, 2011). Gain goals present personal resource advantages, typically of monetary form, e.g. the belief in sufficient yield of a cropping system motivates the gain perception (Rodriguez et al., 2009). Normative goals incorporate the intention "to act appropriately" or "to do the right thing" (Etienne, 2011). Normative frames are the embodied motivation for pro-environmental behavior. Normative factors can, but rarely have a direct consequence for the decision maker, though they matter within a social or environmental context. Hedonic goals describe the mood or the joy that steers behavior, which, even in business decisions, have some role to play. As discussed, MC imposes a more complex cropping system, which some actors might embrace as a challenge to their capability, while others perceive it as a cognitive barrier or unwanted labor task. Each psychological category contributes objectives to trail MC. MC's compatibility with those motivations may enhance or diminish adoption.

This study operationalizes all three types of objectives and the perception of MC's worthiness in a brief straightforward set of items (Table 2). An exploratory factor analysis, based on collected data, suggested the combining of the items regarding farmer's objectives and MC's worthiness into a single factor that is simply named attitude towards MC throughout the study. The combined factor precludes multicollinearity of these variables in subsequent modelling. Factor loadings, Kaiser Meyer Olkin Criteria (KMO), explained Variance (EV) and Cronbach alpha ($\acute{\alpha}$) are summarized to assess the item's statistical suitability to be condensed into a single factor.

[Table 2 about here]

2.1.3 Farm characteristics and conservation agriculture

Substantial research has identified farm household characteristics, biophysical characteristics and farm management characteristics in the adoption processes of conservation practices. Yet, combining the gained knowledge in reviews has shed light on the contradictory nature of many results regarding no-tillage, reduced tillage, cover crops and other conservation practices (Knowler and Bradshaw, 2007). Such conservation practices have struggled to convince farmers to change their cropping system (Rodriguez et al., 2009) and to convey the advantages of conservation agriculture. We have surveyed salient farm and management characteristics in order to prioritize and validate tangible and objective early adopter properties related to MC. We discuss the results in the context of conservation agriculture research in developed economies like the USA, Canada, Europe and Australia. Intercropping adoption research was neglected, as it is predominantly situated in agricultural systems of developing countries, whose adoption parameters may not suit a comparison.

2.2 Sampling

We opposed several restrictions in order to interview only farm managers for whom MC is a suitable production option. Participants are decision makers of farm enterprises with a stated focus on crops instead of livestock farming or horticulture. The geographical placement of the farms was quoted

on the federal state level in order to incorporate some of the heterogeneity of climatic and socio-economic factors in Germany. The available crop land of each state relative to Germany's overall crop land determined the share of farm manager in the sample[1]. This process directed the choice of telephone numbers. Out of an extensive contact list, owned by a market research company, we randomly selected farms until the state's quota was achieved. Other sample features may not be representative. Data management was simplified via computer- assisted telephone interviews (CATI). The minimum farm size to participate was set at the average farm size in each particular state in order to avoid marginal opinions in terms of decisional power on crop lands. Accordingly, the minimum farm size in Eastern states was around 250 ha, in Southern states 30 ha, and in North-Western states 50 ha[3]. Thus, the sample farm sizes will be larger than the national average. The brief introduction of MC ensured an equal understanding, though leaving room for two types of application for cereal-legume mixes. The first application is to harvest both crops, a second is to leave the legume crop as fertilizer and cover crop on the field.

In cooperation with a market research firm we executed 152 telephone interviews while we approached 4422 farm managers during March to May 2016 (response quote: 3.4 %). Many farm managers were not interested, not reached or asked to postpone the telephone interview beyond the data collection time frame. Some farm businesses were thinking about resigning agricultural production or have already resigned. Other farm businesses specialized in tree crops, horticulture, livestock farming or no commercial cropping. These farms were also excluded from this study. Up to 20€ were paid to incentivize participation and to promote truthful information sharing and data quality.

2.3 Data

While the sample is representative regarding federal states, the focus on medium to large farms has returned a sample somewhat different from national averages. The average farm sampled managed 352 ha compared to the national average of 58.6 ha (DEStatis, 2016). Farm size is expected to affect the number of farms that are run as the main source of income (88 % to 48 % (DEStatis, 2016)), which returns a rather professionalized sample. The number of farms that use -at least partially- reduced tillage is high (72.4 % to 34 % (DEStatis, 2016)). A correlation of farm size and reduced tillage is hypothesized (Rodriguez et al., 2009), due to a higher investment capacity in according machineries, but no representative data for Germany was retrieved. Not necessarily affected by farm size, but still noteworthy are age and land tenure. The sample is biased towards older farm managers, especially interesting in adoption research, as modern survey techniques, e.g. internet surveys, may under-represent their opinions. Decision makers age is distributed as follows: under 45 years: 16 %, 45-54 years: 28 %, 55-64 years: 44 % and older 12 % compared to a national distribution: under 45 years: 26 %, 45- 54 years: 38 %, 55-64 years: 29 % and older 7 % (in 2013) (DEStatis, 2016). The share of land owned by the farm enterprise is somewhat higher (46.1% to 39% (in 2010) (DEStatis, 2016)). All modelled sample characteristics are summarized for further assessment (Table 3).

[Table 3 about here]

[1] The crop land per state (%) and average farm size per state (ha) was based on data of the federal ministry of Statistics DEStatis (2016): In the modelling section we summarize the states aggregated to 3 regions: North-West (SH,NRW,NS) 30.2 % (Ø: 58.5 ha/farm), South (B,BW,SA,RP,H) 36.7 % (Ø: 36.2 ha/farm), East (S,SA,T,MV,BB) 33.1 % (228.3 ha/farm)

2.4 Data analysis

Data cleaning and other calculations are executed via the Stata software package. Adoption models are usually analyzed with regressions based on logistic or normal distributions (probit models) (Knowler and Bradshaw, 2007). In this study, the 4 stages of trial willingness, precontemplation, contemplation, preparation and action, impose an ordinal variable structure. The proportional odds model for ordinal logistic regressions is used to explain the relative likelihood to switch the stage of trial willingness in respect to a driver (Grilli and Rampichini, 2014). In this model the ß coefficients represent the odd ratios of switching to a higher stage vs. no switch or switch to a lower stage for a one unit change of a driver, keeping all other drivers constant at the mean. The model is estimated using the maximum likelihood approach. Such a model can be thought of as multiple binary logistic regressions on the relative probability to be in one category rather than the next lower one. The proportional odds assumption or parallel regression assumption, i.e. the assumption that the beta coefficients are equal across all ordinal stages, is tested via Brant test (Guzman-Castillo et al., 2015). The Brant test statistic implied a violation of the assumption ($p>chi^2 = 0.002$). Instead of switching to an alternative model, like multinomial logit or generalized ordinal logit, which cannot equally account for the ordinal nature of the dependent variable, we chose to combine stage 3 and 4, that have suffered from low group sizes (stage 3: N=18, stage 4: N=11). The combined stage of preparing and implementing Mixed Cropping solves the assumption's violation ($p>chi^2 = 0.252$) and allows for a proportional odds model. Intermittent missing data has been a minor issue, due to the trained interviewers. However, after selection of the model variables three observations do not provide the full information required. Given the exogenous nature of the missing characteristics, imputation methods did not seem appropriate, so the concerned observations are dealt with by case-wise deletion. Some variables have not been modelled, due to a low statistical variance, e.g. organic farms and female decision makers represent 2.6% and 3.9% of the sample. To ensure the absence of multicollinearity the VIF test statistics and bivariate correlation were assessed (mean VIF=1.6, max VIF=2.3, Corr: all $r<0.45$[2]). Model fit is assessed by the means of correctly predicted observations, Pseudo R^2 and the Chi-squared value. We additionally present the descriptive statistics of independent variables disaggregated for the 3 modelled stages of the TTM model (Table 3).

3. Results

A Mixed Cropping Adoption Model and Limitations

The ordinal logit model helps to understand the relationship of MC adoption with the outlined perceptions regarding technical barriers and the attitude towards MC. The model also sheds light on farm characteristics that identify potential early adopters by frequently surveyed information. The ordinal dependent variable reflects the adoption stages regarding MC, namely precontemplation, contemplation, preparation and action. The self-reported stages may be affected by pro-innovation bias, as not every farmer has been aware of the possibility of an MC application (73.5 % of respondents agreed or strongly agreed to be aware of MC practices), so this study's adoption model controls for prior awareness. Another potential bias is social desirability that may cause farmers wanting to comply with a higher stage of trial willingness than they actually feel comfortable with. As the practice MC is currently not socially demanded within the public or farming community and as our telephone interviewers have had prior experience with surveys, we believe this bias to be minimal. The

[2] Exceptionally the different regions are by definition of dummies negatively correlated r=0.48-0.52

cross-sectional nature of the data allows for an analysis of the reference year 2015, but is time invariant. The time invariance prohibits a meaningful application of the 5th TTM stage, i.e. the maintenance of a behavior or practice. Additionally, the cross-sectional survey data is not particularly suited for a causal analysis of drivers. The characteristics in the proportional odds model shall be interpreted as associated or related to MC adoption.

The model finds that the following variables are positively related to MC adoption, significant at the 0.05 level: (1) the legume area cropped as share of farm size, (2) conservation tillage adoption, (3) the share of owned land relative to leased land, (4) the attitude towards MC (Table 4). Cover crop adoption is significant at the 0.1 level. In contrast, (5) technical barriers are significant antagonists (Table 4). A comprehensive adoption picture also draws on the non-significant findings, so we will discuss both types in the context of CA-adoption. The selected model provides odds ratios to estimate the relative probability to trial with respect to a one-unit difference between individuals, e.g. a one percent higher share of legumes cropped is associated with a 1.2 times higher probability to be in the next stage of adoption. An odds ratio close to one suggests little probability change within the distributional range of a variable with respect to adoption stages. The odds ratios may be used to forecast an adoption potential of farmers, but the characteristics may change along the way, once a diffusion process progresses (Feder and Umali, 1993). Currently, the findings are valid within the distribution of the underlying variables, e.g. a non-significant effect of farm size shall only be expected among a sample restricted to large or comparable farms. We add 95 percent confidence intervals (CI) to indicate lower and upper bounds of the odds ratios. Consistent with demands on statistical reporting (Zhu, 2012) CI and odds ratios allow for an improved evaluation of effect stability relative to simply reporting p-values (Table 4). The complemented graphical illustration supports a quick overview on these statistical parameters.

Overall the model predicts well who is generally not willing to trial MC (sensitivity 78.3 %) and who does not belong to the group of farmers that expressed precontemplation (specificity 85.9 %). The model predicts precisely who is currently not trialing MC (specificity 93.9 %), but is comparably less helpful to predict who currently adopts (sensitivity 41.4 %). Other model fit criteria imply quite an acceptable model fit with a decent Pseudo R^2 (0.33) and a significant chi-squared value ($p=0.0000$). The result is a unique case study on MC and can be complemented by research in several biophysical, socio-economic and other country contexts.

[Table 4 about here]

4. Discussion

4.1 Farmer's perception of Mixed Cropping

The perception of technical hurdles hinders adoption significantly. Farmers, who are more critical of MC specific barriers by one unit, have an almost halved probability to signal adoption tendencies (Table 4). The descriptive statistics reveal that the perception of the coordination of crop maturity and the separation or direct use of harvest is overall perceived more critical than additional labor needs (Table 2), but the barriers are interrelated. The factor analysis has shown that a critical perception of one barrier is closely linked to a critical perception of others and little variance is gained by distinguishing them. An effort to increase MC's diffusion will need to target technical challenges in general and dispel doubts. Note, the perception of barriers does not necessarily reflect the real challenges involved in adoption, as is known from risk perceptions (Rodriguez et al., 2009). However,

up to today socio-economic studies have not researched the additional costs or summarized the deviating tasks. The knowledge could help to direct future research and improve transparency on time and costs to oppose unjustified perceptions. This will lead to a better idea of how to market MC, as, based on this study, we learn who to market it to.

Besides legume cropping the attitude towards MC, i.e. the perception of MC's worthiness and compatibility with farmer's objective, has been the most significant indicator of adoption (Table 4). On average farmers are skeptical that MC can improve any of their objectives in farming (Table 2). All item's averages are between neutral and disagreement towards a positive attitude to MC, but those farmers, who have a positive perception, signal four times the probability to become an adopter (Table 4). As this study has not attempted to communicate the different ecological advantages, we know little about prior knowledge and acceptance of such benefits. A communication strategy can strengthen the salience of normative goals in agriculture in relation to MC. E.g. the rising public interest in biodiversity (Novacek, 2008) may increase biodiversity's importance in agricultural evaluations. An efficient communication of the link between biodiversity, associated biodiversity and multi-cropping systems may enhance the normative perception. The growing scepticism of Europe's dependence on soy imports to the livestock sector (Lucas et al., 2015), provides a further normative argument, as MC offers an additional system to integrate indigenous legumes in crop rotations. Similar arguments can be made for other ecological benefits, like the reduced synthetic fertilizer needs, water use efficiency or the reduced risk of soil erosions (see Introduction). Nevertheless, a knowledge gap remains on how the ecological benefits translate into economic profitability. An improved transparency on costs and benefits could greatly reduce adoption uncertainties and enhance the gain perception of MC.

4.2 Crop management characteristics and Mixed Cropping

Legume cropping: Importance of legumes has declined in Germany since 2003. The area cultivated with legumes has dropped by 131000 ha between 2003 and 2013, which accounts for 63.4 % of the original cropping area (FAOSTAT, 2015). Among the economically relevant legumes - peas, fava beans and lupins - all can be intercropped with different cereals. The use and maintenance of legumes systems increases significantly the trial willingness for MC. Farmers with just 1 % more crop land distributed to legumes have a 1.2 times higher probability to trial MC (Table 4). Such farmers are experienced in legume crop management and are very aware of the soil benefits of legumes. The success of recent legume promotion strategies, like the "UN's year of pulses" or the EU's common agriculture policy (CAP) incentives will indirectly affect the adoption of MC. It remains to be seen, whether legume cropping dissemination picks up and thereby increases the salience of MC within the agricultural sector.

Crop diversity: A large field crop diversity suggests that a farm manager cares about agrodiversity and has a preference for multifaceted cropping systems over less diverse systems. However, such a preference has not been significantly related to MC adoption. While crop diversity, among harvested crops, may increase the adoption of cover crops (Arbuckle and Roesch-McNally, 2015), such a cropping characteristic applies not to MC-adoption tendencies in our sample.

CA-practices: The adoption of CA-practices starts with a farm operator's perception that current practices hazard a sustainable production environment and create soil problems (Gould et al., 1989). Such a perception can cause a common sensitivity to CA-options. However cover crops and reduced tillage were contrasted as two distinctive crop management strategies to regulate weeds in European

organic farming systems (Peigné et al., 2016)[3]. However crop management strategies do not suggest to neglect MC, if other CA practices are applied. Interestingly, reduced tillage stands out among CA-practices to be significantly related to MC. Prior investments in reduced tillage equipment present an undoubtable commitment to CA-objectives. Especially farmers fully rejecting MC have made significantly less use of reduced tillage (Table 3), but frequently they applied only conventional tillage. By 2010 34 % of German farms have adopted reduced tillage (DEStatis, 2016)[4]. Often reduced tillage is carried out by large farms in comparison to other European countries[5]. As structural change promotes farm growth, large farms are increasingly common in the agricultural sector. Regarding cover crops this study finds weak evidence to confirm a relation to MC in crop management (Table 4). Generally, cover crop mixes tend to consist of legumes, so that farm managers gain additional experience with legumes. Therefore cover crops may add an indirect effect on MC adoption via an enhanced relevance of legumes. Additionally a few farmers intercrop cereals and legumes, mainly to leave the legume as cover crop in the field (Peigné et al., 2016).

4.3 Farm Manager Characteristics and Mixed Cropping

Education: CA-reviews find education positively related to adoption of CA practices, although the major share of the effects are not significant (Knowler and Bradshaw, 2007). The declining number of family farms and an increasingly educated labor force may diminish the effect of education in adoption processes (Pannell et al., 2006). Although formal education may initiate a change in environmental attitudes and can enhance processing of information, these attitudes are not necessarily translated into behavioral change (Burton, 2014). On the contrary, arguments are expressed why education may nevertheless play a positive role. The technical skills and familiarity to implement innovations and the ability to cope with administration required to collect additional monetary benefits reduce technical and economic barriers that are particularly interesting to MC, which challenges the farmer to find efficient solutions for the technical work-flow of a multi-cropping system. While college education has been positively related to conservation tillage (Fuglie, 1999), agricultural college education and MC appear unrelated. Counterintuitively agricultural college education decreases MC adoption among the sample at hand, though not significantly. Some contradicting findings have been explained by two very different education concepts. While agricultural education may promote conventional practices, general/formal education may enhance CA (Pannell et al., 2006; Murphy et al., 2011), but a comparison of graduated from agriculture study program and alternative agriculture education has not revealed findings in line with formal education effects.

Age: Multiple factors correlate with age, including a raising experience and rigid attitudes (Rodriguez et al., 2009; Burton, 2014). The heterogeneous effects of age can make it difficult to determine a significant effect direction. In case a factor related to age is dominant, the heterogeneity is captured by farm manager's age. In our findings age is not specifically associated with MC's adoption (Table 4).

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[3] This case study finds a bivariate correlation of cover crops and reduced tillage of close to 0 (r=0.025).

[4] ELPM (Survey on agriculture production practices) data of the German Federal Ministry of Statistics

[5] German farms with over 150 ha manage 65 % of all land managed which is among the highest shares of large farms in the EU (Eurostat 2016, http://ec.europa.eu/eurostat/statistics-explained/index.php/Agri-environmental_indicator_-_tillage_practices). At this point no panel data on reduced tillage was retrieved.

4.4 Farm Characteristics and Mixed Cropping

Land tenure: Whether land is owned or leased has predominantly been an insignificant factor, with rare positive and even rare negative relationships in CA-adoption research (Fuglie, 1999; Knowler and Bradshaw, 2007; Arbuckle and Roesch-McNally, 2015). Land tenure effects may be balanced out by long-term leasement agreements (Fuglie, 1999). In contrast to prior CA-findings, we point out a significant role of land ownership. The descriptive statistics (Table 3) reveal that especially the share of owned land among farm managers with contemplation towards MC is higher than the owned land share among the ones with precontemplation. The argument that the long-term orientation of field management depends on the ownership contracts is a reasonable assumption put forward (Knowler and Bradshaw, 2007). The assumption is especially valid for long-term advantages of MC like an increased water use efficiency that will be particularly valuable for yields in years with significant drought damage. Conclusively ownership of land helps to profile potentially interested farm managers. Between 2007 and 2010 the share of owned land has increased by 2 percent (DEStatis, 2016), which equals 1.04 times the probability of to be a potential MC adopter (Table 4).

On-farm income: If the farm is the main source of income, the tendency to adopt more profitable production methods can increase even if greater management demands are involved (Pannell et al., 2006; Rodriguez et al., 2009). The off-farm occupation may raise interest in production practices that reduce farm labor demand (Fuglie, 1999). Off-farm income might divert attention away from professionalization of farm enterprises, so the interest in management changes and novel adoption is reduced (Knowler and Bradshaw, 2007). The enhanced financial security of an off-farm occupation can increase investment capacity, but will play a minor role among large farms. The overall effect on adoption is positive, but insignificant and may not be used to profile MC adopters.

Farm size: Investment in reduced tillage equipment were found not worth it in small enterprises (Rodriguez et al., 2009). In coherence positive or non-significant relationships between conservation tillage/no-tillage and farm size were found (D'Emden et al., 2006; Knowler and Bradshaw, 2007). Specific or indispensable investments for MC are not known and a sample with a focus on rather large farms may exclude farms for which such an argument would have been valid. We find no indication that farm size is related to adoption (Table 4).

Livestock Farming: Livestock is not a focus point of CA adoption research in developed countries. Cropping and livestock are often seen as two separate farming divisions, but the specific case of MC is linked to livestock. The harvest of mixed crops is difficult to market before the crops are separated, but the mix can be fed to cattle or pigs and therefore work around the technical task of separation. No significant results were found for increased trial willingness of MC in mixed livestock and cropping farms. Although the probability of livestock farmers to adopt MC is about double of pure cropping farms (Table 4), the variance has been too large to detect a significant effect at standard significance levels.

5. Conclusions

The Transtheoretical model (TTM) has allowed for a more detailed analysis of both, potential and actual adopters of Mixed Cropping (MC). The model is simple to apply in questionnaires and can be analyzed with common statistical models. Environmental and political communication strategies can benefit from results obtained through the TTM, as we learn to target potential adopters instead of unwilling or already convinced farmers. Communication strategies can be designed for the stage of

adoption that the majority struggles to take. This study presents, to the best of our knowledge, a novel application of the TTM in adoption research and a novel case study on adopter characteristics of MC. MC has not been of interest to most agriculture stakeholders, due to technical challenges and minor adoption rates (AMI, 2014), but MC is a viable practice that suits the agenda of conservation agriculture even in developed countries. Its ecological benefits can contribute to a more sustainable land use. Renewed signs of diffusion can set MC on the agenda of policy makers and NGOs, where it fits nicely with increasing demand for sustainability, biodiversity preservation, reduced synthetic fertilizer use or reduced pesticide applications. As other conservation practices, MC will need to overcome farmer's concerns, such as a limited compatibility with a farmer's existing set of technologies and resources, labor efforts required for crop management and the lack of specific political support (Pannell et al., 2006). In the end, MC's diffusion will be a process of learning to fill knowledge gaps at the farm level. Early Adopters can play a key role in supporting this learning process. Current adopter characteristics comprise the cropping intensity of legumes, the share of owned in comparison to leased land, the adoption of reduced tillage and cover crops. We have briefly discussed the expected development of those characteristics. Prevailing MC will need to convey its worthiness to farmers and dispel doubts on its technical feasibility, so that a diffusion process can be initiated. It should be noted that characteristics might change over time once the diffusion process progresses (Feder and Umali, 1993).

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Table 1 The Transtheoretical model to adopt Mixed Cropping

Stage	**Concept**	**Operationalization**
Precontemplation	no intention to change, lack of motivation or information to change	"I am not willing to trial MC"
Contemplation	intention to change, still considering associated costs and benefits	"I am generally willing to trial MC, but do not know how"
Preparation	intention to change with a concrete plan of action	"I look forward to trial MC and know where to start"
Action	behavior has changed	"I work with MC in my crop rotations"

Table 2 Farmer manager's perceptions of Mixed Cropping

Items – strongly disagree (1) to strongly agree (5)	Mean (SD)	FL
Factor 1: Attitude towards MC ά=.86, KMO=.81, EV= .71		
I see the advantage and long-term potential of Mixed Cropping (worthiness)	2.42 (1.15)	.89
I enjoy new challenges and tasks like Mixed Cropping (hedonic)	2.32 (1.29)	.79
I think Mixed Cropping can improve my cropping plan in the long run (gain)	2.53 (1.27)	.86
I think Mixed Cropping is useful for the whole agricultural sector (normative)	2.68 (1.31)	.83
Factor 2: Technical Barriers ά=0,76, KMO= 0.76, EV= 0.6		
I consider the parallel coordination of crop maturity to be difficult	3.51 (1.16)	.79
I consider the separation or direct use of a mixed harvest to be difficult	3.51 (1.39)	.66
I consider the additional labor for drilling, harvest etc. to be overburdening	3.15 (1.21)	.81
I consider the practical implementation to be challenging	3.08 (1.14)	.81

Factor loadings (FL), Kaiser Meyer Olkin Criteria (KMO), explained Variance (EV) and Cronbach alpha (ά)

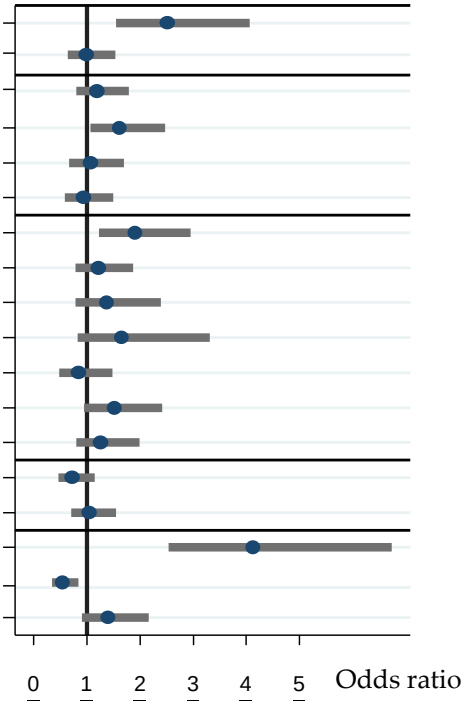
Table 3 Descriptive statistics of variables used in regression analysis by adoption stage

	Variables-Set	Scale	Total Sample	Sample by stage of Trial willingness		
			Mean (N=152) (SD| Median)	Precontemplation (N=60)	Contemplation (N=63)	Prep. And Action (N=29)
Crop management	Legumes cropped	% … per total land managed (2015)	2.65 (4.97| 0)	1.54 (2.9| 0)	2.17 (3.8| 0)	5.96 (8.3| 0)
	Cereals cropped		51.82 (17.7| 53.6)	53.44 (15.7| 55.8)	52.83 (17.9| 54)	46.24 (20.4| 51.4)
	Cover crops	1 If … practice was applied (2015)	.638 (.48| 1)	.566 (.50| 1)	.683 (.47| 1)	.690 (.47| 1)
	Reduced tillage		.724 (.45| 1)	.633 (.49| 1)	.794 (.41| 1)	.760 (.44| 1)
	No-tillage		.197 (.4| 0)	.233 (.43| 0)	.159 (.37| 0)	.210 (.41| 0)
	Crop diversity	Sum of field crops (cereals, legumes, maize, sugar beets etc.) (2015)	5.07 (1.88| 5)	5.08 (1.9| 5)	4.83 (1.7| 5)	5.55 (2.1| 5)
Farm and manager characteristics	Farm size	In hectare (ha)	352.1 (576| 150)	331.43 (490.4| 139)	387.76 (690.3| 140)	317.5 (471.5| 200)
	Northern states	% of farms in … states	31 (46.6| 0)	35 (48| 0)	31.7 (47| 0)	24.1 (44| 0)
	Eastern states		34 (47.6| 0)	40 (49| 0)	30.3 (46| 0)	31.1 (47| 0)
	Southern states		35 (47.6| 0)	25 (44| 0)	38 (49| 0)	44.8 (51| 0)
	Land tenure	% owned land per total land managed (vs. leased) (2015)	46.1 (25.2| 47.2)	43 (25.8| 40.7)	49.4 (25.6| 50)	45.6 (23.1| 43.3)
	On farm income	1 if farm is the owner's main source of income	.88 (0.33| 1)	.83 (.38| 1)	.92 (.27| 1)	.86 (.35| 1)
	Labor availability share	Employees (incl. family labor) per 100 ha (part time=0.5 employees)	2.90 (1.88| 2.46)	2.67 (1.6| 2.24)	2.98 (1.95| 2.5)	3.20 (2.27| 2.63)
	Livestock farming	1 if livestock turnover more than 5% of total	0.380 (.49| 0)	.316 (.47| 0)	.365 (.49| 0)	.517 (.51| 1)
	Education	1 if graduated from agricultural university	0.3 (.46| 0)	.4 (.49| 0)	.25 (.44| 0)	.21 (.41| 0)
	Age	Years	53.6 (10.8| 55)	55 (10.2| 57)	52.9 (10.7| 55)	52.3 (12.2| 54.5)
Percept.	Attitude to MC	4 item, factor (Table 2), Min=-1.54, Max=2.67	0 (1| -.06)	-.68 (.67| -.73)	.26 (.78| .15)	.83 (1.1| .98)
	Technical barriers	4 item, factor (Table 2), Min=-2.49, Max = 1.85	0 (1| -.03)	.24 (1.03| .44)	.04 (.9| -.12)	-.57 (.94| -.43)
	Prior awareness	(1=strongly disagree, 5= strongly agree): "I am already aware of mixed cropping" [a1]	3.99 (1.29| 4)	3.68 (1.4| 4)	4.05 (1.22| 4)	4.48 (1.02| 5)

Table 4 Ordinal Regression - Characteristics of gradual Mixed Cropping adoption

	Variable-Set	**Odds Ratio**		**p>|z|**	**CI 95%**	
		Odds	SE			
Crop Management	Legumes cropped	1.195	.056	0.000	1.08	1.31
	Cereal cropped	.9958	.011	0.748	.972	1.01
	Cover crops	2.272	.991	0.072	.966	5.34
	Reduced tillage	3.087	1.52	0.029	1.17	8.14
	No tillage	.9847	.533	0.980	.340	2.84
	Crop diversity	.9329	.119	0.611	.726	1.19
Farm and manager characteristics	Land tenure	1.022	.008	0.010	1.00	1.03
	On farm income	1.765	1.16	0.519	.487	6.39
	Region North-West	1.937	1.15	0.257	.599	6.25
	South	3.451	2.52	0.138	.822	14.4
	Labor availability	.8514	.136	0.413	.622	1.16
	Livestock farming	2.073	.991	0.165	.812	5.29
	Farm size	1.000	.000	0.393	.999	1.00
	Education	.5362	.269	0.188	.200	1.43
	Age	.9959	.018	0.816	.960	1.03
Perceptions	Attitude to MC	4.111	.992	0.000	2.56	6.59
	Technical barriers	.5779	.124	0.021	.378	.882
	Prior Awareness	1.190	.201	0.310	.854	1.65
	N			149		
	Pseudo R^2			0.33		
	Likelihood Ratio chi^2	102.8		Prob	0.0000	

Illustration Odds and CI (standardized)[1]



Sensitivity to predict Precontemplation: 78.3 %, Contemplation: 69.3 %, Preparation & Action: 41.4 %

Specificity to predict Precontemplation: 85.9 %, Contemplation: 63.8 %, Preparation & Action: 93.9 %

CI = confidence intervals, [1]to compare the odds ratios the variables have been z-standardized and graphically illustrated

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Article 2: The value of environmental and health claims on new legume products: a non-hypothetical online auction

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Abstract:

Legumes are valued in agricultural systems, as they can contribute to a more sustainable land use. However, their economic value is low. Despite health and environmental benefits, marketers struggle to communicate the worth of legumes to consumers. We evaluate the worth of health and, in particular, environmental claims that would spread consumers' awareness of ecological advantages. Utilizing a large consumer sample, we execute binding online auctions. Comparing claim-treated and untreated subjects (between design), we model the price premium that potential customers are willing to pay (WTP) for having pasta in a legume instead of a wheat version. We find that claims may increase the WTP, however, a mix of environmental and health claims is superior to individual claims. Effect sizes suggest that the mix of claims increases the WTP by roughly 35% (20 Euro cents). The link of WTP and food attitudes, such as concern for health in eating habits or social reservations towards legumes, varies depending on whether the green-pea or chickpea pasta was evaluated. A critical perception of legumes' association with flatulence reduces the WTP. Developing the online auction may enable researchers to increase the external validity of consumer samples. We discuss implications for researchers and marketers.

Keywords: pulses; experimental auction; sustainability labels; credence attributes

1. Introduction

Legumes summarize a family of plants, e.g., peas, beans, lupines, and more, that have all struggled to be marketed for human consumption in western countries. Their dietary fibre content is highly recommended by nutritionists [1], but the consumption averages were just around 4 g/capita/day (beans, peas, soybeans and other pulses) in Germany and 7–8 g in Europe, while the world consumes on average around 24 g/capita/day [2]. Medical literature supports nutritional recommendations, as legumes protect against coronary heart disease, type II diabetes, and high blood pressure [3,4]. Some researchers have highlighted the lack of publicity and the lack of modern marketing campaigns surrounding these commodities [5,6]. Such marketing efforts could address health and ecological advantages, which are important selling points of legumes [5], and have sustained the agricultural interest. Legumes attract bacteria that fixate atmospheric nitrogen, utilize nitrogen, and make it available in crop rotations. Multiple benefits go hand in hand with legumes' nitrogen fertilization. The fixation of nitrogen diminishes the eutrophication of water courses by mineral fertilizers [7], reduces the emissions of the greenhouse gas nitrous oxide [8], and prevents carbon dioxide emissions related to fertilizer production. The energy costs of nitrogen fertilizers are substantial. N-fertilization has been responsible for 52% [9] of all energy used in the agricultural cropping process. N-production and use remains a key issue of agriculture [10].

Besides the lack of marketing campaigns, researchers have described a lack of innovation [6]. Today, as well as in the previous decades, most legumes are sold in cans, followed by dried produce [6]. Packaging and distribution have hardly been changed [5]. However, some new legume products have entered retail, and are in the process of creating niche markets. Due to good processing qualities with respect to solubility, water binding capacity, fat binding, emulsifying, and foaming, legumes can be implemented in many convenience products [11]. Companies have utilized these processing characteristics in order to create innovative products. Lupine ice-cream or lupine yoghurt were developed to substitute milk for vegans and lactose intolerant consumers, while retaining texture and protein content. Another product is pea or chickpea pasta, which substitutes wheat to target consumers who are wary towards gluten. Pea milk or lupine spreads are also marketed. However, these products are specifically designed to substitute a certain ingredient for nutritional reasons. We are not aware of any efforts to develop the consumers' image of legumes in general, or to utilize their ecological advantages in product communication. Especially, new products may be able to create new and positive perceptions with consumers. Such product communication may reduce the environmental impact of food consumption by influencing purchase behaviour [12] in favour of legumes.

Product claims, i.e. health and environmental claims, are an opportunity to communicate product advantages that shall lead to a higher WTP and additional demand for legume products. The worth is not limited to individual products, but claims, as a common form of product communication, can highlight positive features of the whole product category. For example, cereal processors have undertaken proactive campaigns and claim marketing with a considerable reach to increase consumers' awareness of the health benefits of cereals' fibre content [13]. An increased knowledge of legume benefits may trigger behavioural change and enhance consumption. Claims are known to enhance demand [14,15], as they make it easier for consumers to justify a decision [16]. Consumers tend to believe claims' content [14]. However, Mialon et al. [17] have analysed fibre claims on bread and muffins. They suggest the effect is small or non-existent, because most consumers are already aware of products' fibre content. Assuming a low level of knowledge on legume benefits, legumes are

particularly suited to analyse a claim effect. The benefits may not be perceived by everyone and will vary by the information provided. The effect a claim has on consumers will also vary by individual characteristics or food attitudes, such as social norms [18], consumers' price sensitivity [19], the motivation to act on health information [13], and probably many more. Surprisingly, the major challenges of healthier and environmentally friendlier consumption are rarely examined simultaneously in relation to claims, which are so commonly used in product marketing. Many products do not qualify for both types of claims. So far, health practitioners and green marketers have tended to focus on either health or environmental marketing, depending on the regulatory framework given to them. Therefore, we know little about how a mix of health and environmental attributes performs relative to individual health and environmental claims.

To evaluate the direct worth of claims to different consumers and encourage the legume processor's use of it, we designed an experiment where we auctioned off new legume products under different claim conditions. The claims are applicable to and admitted for the legume products under research in the following, but are certainly not limited to them. We assess the value of the claims individually and combined in order to analyse the advantage of incorporating both health and environmental claims. Food attitudes that go hand in hand with a higher valuation of the products are also considered. To produce reliable evidence, we propose two research necessities. Prior studies have emphasised the need to avoid purely attitudinal studies and build on non-hypothetical behavioural measures. "Consumers talk health or talk green, but don't walk it" [20]. An auction shall separate what they say from what they pay [21]. In addition, external validity is often an issue in samples recruited for on-site laboratory experiments [22]. Low external validity may cause an overestimation of the effect magnitudes. In an effort to resemble the marketplace, we execute an online auction with a quoted sample of household shoppers, representative in age, gender, and income. Before presenting the results, we discuss health and environmental claims and the specific features of our online auction; a singularity of this study.

2. Operationalised Health and Environmental Claims

Green peas are the majorly grown legumes in the EU [2]. We evaluate green pea pasta (PP), as pasta is a popular product that most consumers know how to utilise. It is a pure product derived from 100% pea flour to avoid distortion by consumers' perception of additives and so on. To anchor our findings, we also evaluate chickpea pasta (CP). Particularly, CP has been proven to increase the glycaemic index less than wheat pasta [23]. The substitute, classic wheat pasta (WP), is also auctioned. All the pastas are presented in see-through foil with a package size of 250 g (see product pictures, Appendix Figure A1). All the pastas are available in German and Dutch retail outlets.

To initially test the value of legume benefits in marketing, we select two health and two environmental claims, applicable to legume pasta. The claims are tested individually and in a combination of both health and environmental claims. The claims refer to protein content (H1), fibre content (H2), mineral fertiliser (E1), and carbon emissions (E2). All the claims are structured similarly and are presented on the product visuals used in the auction (Appendix Figure A1). Several studies have found claims to influence willingness to pay (WTP) with consumers [24–26]. Effects can exist regardless of whether the advantage is of immediate concern to the consumer, as found for health claims on cholesterol [24]. A believable claim should increase WTP, if other product features are not compromised [26]. However, the effect is expected to be rather heterogeneous. For example, many

consumers react positively to health information, but not all appear to place a monetary premium on health attributes [26].

The legislative framework of health claims requires extensive and generalisable research to avoid incorrect claim assignments, so most products may only carry a nutritional health claim. Indisputably, legumes provide rich protein and rich fibre content. The fibre content can also be linked to health benefits [11,27]. In consideration of the current legal framework of legumes, we select the fibre and protein content claims. The content is particularly different between legume and conventional pasta. The EU regulates the percentage required to use claims, respectively. The following claim can be made on the legume pasta used: "high in protein". The protein energy share in providing kcal needs to be larger than 20% (PP = 31%, CP = 20%, WP = 13%). The "high in fibre" claim requires a content greater than 6 g per 100 g (PP = 16.6g, CP = 14 g, WP = 3 g) [28]. Standard wheat pasta does not fulfil the requirements for these claims. The fibre content has been of interest to health practitioners and marketers [17,25,26]. Dietary fibre claims have been analysed with respect to bakery products. While the claim "high in fibre" (H2) has been found consistently to enhance product liking, flavour, and healthiness perceptions, the effect has not always been significant [17]. Products that are commonly perceived to be high in fibre may not be affected by fibre claims [17]. An experimental auction on French baguettes with a "source of fibre" claim revealed a WTP increase of around 12% [25]. In contrast, protein claims have not been studied to the best of our knowledge, despite protein content being a common claim in the marketplace, for example dairy products by Arla Foods. Such claims are attribute-based and describe a product attribute and not the utility derived from it. Permitted utility claims are limited; see the EU Commission for authorised claims [28]. Protein sources may mention a positive effect on bones and muscles. Legume claims describing the utility derived from fibre are currently neither admitted nor filed. The success of the claims in marketing depends on consumers' expectations, with respect to fibre and protein.

While prior findings have favoured shorter claims [29], environmental labelling research has found just "environmental friendly" to be too vague to be convincing [12]. A concrete attribute claim may have just the right information structure for consumers to be affected. Some consumers indicate a general preference for products labelled with their carbon footprint [30,31] and might be persuaded to change their valuation of legumes based on carbon information. We assume lower carbon emissions for the legume pasta. From life cycle assessment research, it is known that legumes are one of the most climate-friendly sources of protein [32]. Compared with common plant-based calories, like wheat, legumes are expected to demand a lower carbon footprint. For example, peas have been shown to demand approximately half the non-renewable energy input per hectare, while the output gap is smaller, leading to a significantly better energy output/input ratio than winter and summer wheats [33]. The carbon advantage can be attributed to savings on nitrogen fertilisers. The EU has sued Germany with respect to the violation of agreements on nitrate application. Prior studies have confirmed that cropping details on chemical applications can affect WTP. Precise environmental information on pesticide use with apples enhances the WTP for offerings without it [34]. A contingent valuation with detailed information on farming systems and sustainable pesticide use substantially increases consumers' valuation of fruit and vegetable baskets, although it discourages the major share of low-income consumers from purchasing [35]. Legumes' ability to fixate nitrogen and evade corresponding agricultural needs holds an advantage that consumers may value, if they perceive the issues surrounding mineral fertilisers to be alarming.

3. Experimental Design

The experiment was split into four blocks. Before the first block consumers are asked to declare readiness to participate in a binding auction and their involvement in household's food shopping. The first block evaluates socio-demographic characteristics in order to guide a good representation of German consumers, with respect to gender, age, and income. The second block evaluates attitudes towards food. The attitudes control for some of the heterogeneity between consumers. Next, consumers are directed to the auction platform, where they have to agree to the terms and condition of the auction before they can place a bid. The auction process is combined with control questions to ensure auction comprehension, and the reading of claims on the product visuals. The experiment closes with product specific questions. We explain the food attitudes and, especially, the auction mechanism in more detail in the following.

3.1. Food Attitudes

With a group of marketing researchers we selected attitudes that may be linked to the WTP for legume products. We briefly state the idea behind the concepts. The willingness to act on health information differs between individuals, and will affect the demand for healthier products [17,29,36]. Regarding purchase motives, the straightforward role of sensory characteristics, like appearance, has been established [17]. A meta study by Moser et al. [37] found visual appeal to be a major determinant of fruit and vegetable purchases in Europe. The next concepts relate to the price sensitivity that may explain restrained biddings. Legume-specific social barriers have been derived in qualitative interviews [5,38]. Social desirability and flatulence appear to be salient concerns stated by consumers [38]. Altogether, the evaluated concepts are (the source of the items is cited following the concept title): concern for health in eating habits [39], visual (product) attractiveness [40], consumers' price sensitivity [19], and the perception of social barriers with respect to legume consumption [5,38]. A confirmatory factor analysis condenses the items into factors (Table 1). Five food choice factors are derived. The perception of flatulence differs from the other social barriers considered. Due to the frequently expressed objections caused by flatulence [6,38], it is evaluated as an individual barrier. Other items are dropped if the factor loadings are smaller than 0.6. The visual attractiveness of pea and chickpea pastas appears to be similar. A positive attractiveness score of one product goes hand in hand with the other. A combined attractiveness factor is used for both products.

Table 1 Confirmatory factor analyses of food attitudes

Variables	Scaling	Wording	Ø	SD	FL
Factor 1: price sensitivity ά = 0.68, KMO = 0.66, EV = 0.61, BT = 0.000					
price 1	LS	I always check prices, even on small items	2.22	1.20	0.63
price 2		I notice when products I buy regularly change in price	1.85	0.99	0.67
price 3		I watch for ads and plan to take advantage	2.19	1.31	0.68
Factor 2: health concern (in diets) ά = 0.8, KMO = 0.81, EV = 0.56, BT = 0.000					
health 1	It is important	keeps me healthy	1.74	0.88	0.80
health 2	to me that the	is high in fibre and roughage	2.48	1.10	0.78
health 3	food I eat on a	is nutritious	1.70	0.86	0.61
health 4	typical day:	is high in protein	2.82	1.12	0.73
health 5	(LS)	is good for my skin/teeth/hair/nails, etc.	2.37	1.14	0.80
Factor 3: visual attraction (of products) ά = 0.76, KMO = 0.68, EV = 0.59, BT = 0.000					
visual 1	LS	This PP is visually appealing	2.50	1.36	0.74
visual 2		This PP is colourful	2.00	1.20	0.80
visual 3		This CP is visually appealing	2.15	1.11	0.75
visual 4		This CP is colourful	1.96	1.03	0.78
Factor 4: social barriers ά = 0.72, KMO = 0.66, EV = 0.65, BT = 0.000					
social 2	Peas and	not classy	4.20	1.05	0.77
social 3	beans are:	poor people's food	4.47	0.83	0.85
social 4	(LS)	consumed only by organic consumers	4.41	0.89	0.79
Factors 5 flatulence perception					
social 1	LS	Peas and beans are promoters of flatulence	2.85	1.18	1.00

SD = standard deviation, Factor loadings (FL), Kaiser–Meyer–Olkin criterion (KMO), explained variance (EV), Cronbach's alpha (ά), Bartlett-Test (BT) p-value, LS = Likert type scale from 1 = strongly agree to 5 = strongly disagree.

3.2. Online Auction Design

A variety of methods can be applied to estimate consumers' willingness to pay for products, each offering advantages and disadvantages. WTP measures based on discrete choice methods are less suitable, because the claims under research are not interchangeable attributes. The high protein content or fertiliser advantages exist with all legumes, and cannot be controlled by the production mechanisms. Food product claims are mostly evaluated with experimental auctions, in which the consumers bid for a product and/or a claim-treated product, e.g., [25,26,39,41].

3.2.1. Auction Mechanism

Focusing on experimental auctions, we avoid hypothetical bias and involve actual product purchase. Vickrey auctions are common to analyse the effect of information on WTP for food products [25,26,39,41]. Vickrey auctions reduce our logistical costs relative to Becker–DeGroot–Marschak (BDM) auctions. A BDM auction creates an unknown number of purchases. A large online sample in a BDM auction may impose high logistical costs, while the Vickrey auction produces a projectable amount of purchases. We apply a standard second-price Vickrey auction. The auction winner is obliged to purchase the pasta for the price of the second-highest bid.

Financial endowments have been found to influence bids [42]. Consumers can be more willing to spend money that they received freely [43]. In this study no financial endowment is paid. Consumers should stand by their bid with their own resources and not be influenced by the endowment. However, it should be noted that survey participation is always rewarded with €2 by the market research agency,

independent of whether an auction is involved. The winning bids are not revealed until after the auction ended, which would also influence bidding behaviour [43]. We advised the participants to reveal their true WTP as the best strategy throughout the experiment.

3.2.2. Online Setting

An online setting is not common for experimental auctions, rather, laboratory experiments are used. The advantages of online settings are the large observation number with low costs, and the reduced risk of participants being interested in pleasing the experimenter. The online sample is an attempt to represent German consumers accurately. The disadvantages may include a lack of personalised instructions on the auction mechanism, product depreciation due to delayed receiving, or the issue of predominant opt-out choices, as participants may not be willing to bid in an online setting. Several steps are taken to minimise the disadvantages. We choose an auction which is simple to explain [26]. After the instructions, we perform a test auction (with a pen), followed by a question on the understanding of the auction mechanism. Instead of one auction for the whole sample, daily ones (5 days) are set up to increase the involvement and reduce the waiting time regarding product distribution. In total, 5 × 3 products (PP, CP, and WP) are auctioned. Consumers are unaware of the number of participants in their session. The number varied between 105 and 335 observations per day. The mean bids between days are predominantly not significantly different. Additional quality checks control for irregular responding behaviour, namely streamlining (the time spent on a set of questions/products) and the overall time spent on the experiment. About 10% of the completed questionnaires had to be excluded due to quality concerns.

3.2.3. Auction Flow

Typically a laboratory experiment moves from a situation of no information, just the product, to full information, with all treatments executed. In contrast to such a within design, the claim-treatments can be assigned between consumers, so that each consumer is presented with the product in just one specification. The between-designed experiment requires larger sample sizes in order to compare well-balanced treatment groups, but consumers are not consciously judging the value of an added claim. Consumers evaluate the product given to them once, which may resemble a retail setting where a product is presented either with or without a claim. The larger sample size in this study enables an application of a between designed experiment.

Consumers are split into five treatment conditions and one control group; each treatment group is presented with a different claim on the product visual (Appendix Figure A1). Participants were not given a channel to interact. The assignment of treatments is unconditionally randomised. The group sizes are not levelled. Exceptionally, individuals have double the probability of being assigned to the control group.

Three bidding rounds are performed. Each round, the bid for one of the products is collected (PP, CP, WP). The products are auctioned in a randomised order, as the first auction may influence the bid for the second one, so order effects could not bias the results. Each auction round has a new randomised process of assigning the treatments. The rounds are supplemented by control questions regarding the understanding of the auction process and the reading of the claims. Each round is binding to the auction winner. Participants agreed to the terms and conditions of the auctions and are made aware that the auction winner will be invoiced afterwards. In agreement with the market

research agency, no further steps have been taken to collect the bids from auction winners. The individual success in the auction is announced to all the participants after the auction ended. The products are sent to the auction winners. The auction process was repeated over 5 days.

4. Results

4.1. Data

In cooperation with a market research agency and an online auction service, we collected 1,020 usable consumer responses. Addressing the response quota, 3,504 consumers decided to start the survey advertised as a "food survey". Roughly two-thirds dropped out, because they did not wish to participate in a binding auction. Similar to laboratory experiments, many people are not willing to take part in such studies. In the final sample, about 35% (N = 356) and 37% (N = 375) are still not willing to place a bid on green pea pasta (PP) or chickpea pasta (CP) (Appendix Figure A2). The Legume products are expected to address a similar consumer group. The willingness to pay for PP (WTP_{PP}) and for CP (WTP_{CP}) are correlated substantially (r = 0.77). In the total sample, PP achieves the highest WTP with 69.7 cents, followed closely by CP with 65.4 cents (Table 2). The retail price in the niche market varies between 2 and 4 €. Only a minority is willing to pay the current retail price (Appendix Figure A2). Roughly 1% of the consumers are willing to pay more than 3 €. The average WTP for wheat pasta (WP) is a fair estimation of the retail price with 45.1 cents (Table 2). Noteworthy, the standard deviation of WP (53.4 cents) is considerably smaller than for legume pasta, which implies a more homogeneous valuation of WP. The WTP gap between PP-WP ($WTP_{PP\text{-}WP}$) and CP-WP ($WTP_{CP\text{-}WP}$) captures the price premium consumers bid for legume pasta and accounts for some of the market competition.

Table 2 Sample characteristics.

		Full Consumer Sample		Potential Customers[PP]		Potential Customers[CP]	
Bids	Scale (N = 1020)	Ø	SD	Ø	SD	Ø	SD
WTP_{PP}		69.7	83.3	112.7	82.4		
WTP_{CP}		65.4	79.8			109.4	79.0
WTP_{WP}	€-Cents	45.1	53.4	56.3	62.9	56.3	54.2
$WTP_{PP\text{-}WP}$		24.6	65.8	56.4	62.9		
$WTP_{CP\text{-}WP}$		20.3	64.1			53.1	61.1
Socio-demographics							
gender	Gender: 0 = male, 1 = female	0.50	0.50	0.52	0.50	0.52	0.50
age	in years	46.8	14.7	46.17	14.1	46.1	14.6
income	1 = < 900 €, 9 > = 6000 € per Household	4.80	2.15	4.82	2.12	4.76	2.14
education	1 = no educational degree, 4 = general qualification for university entrance level	3.32	0.75	3.40	0.71	3.39	0.74
N		1020		601		577	

PP = pea pasta, CP = chickpea pasta, Ø = mean, SD = standard deviation, $WTP_{PP, CP}$ = average willingness to pay for PP and CP, $WTP_{PP\text{-}WP, CP\text{-}WP}$ = average WTP gap between Legume and wheat pasta, Potential Customers if $WTP_{PP, CP} >= WTP_{WP} > 0$.

Turning to the different treatments groups, the randomisation was successful in the sense that socio-demographic characteristics and food attitudes are balanced over the treatment groups, so that we cannot reject the assumption of equal distributions over the treatment groups (Table A1).

Unobserved characteristics are not systematically different between the randomised treatment groups and are expected to be balanced. The descriptive data shows that the control group has a strong tendency to receive for the lowest mean bids, while the mix of all claims has a strong tendency to achieve the highest mean bids (Table 3). Looking into relevant consumers for legume products, the sample needs to be restricted to potential customers. Potential customers are filtered by dropping Zero-bid (opt-out) consumers and consumers who bid less for legume pasta than WP. For these consumers, the average gap between legume and wheat pasta varies between 41 cents and 70 cents (Table 3).

Table 3 Auction bids by treatment.

Bids		Full sample					
		C	H1	H2	E1	E2	Mix
WTP_{PP}	€-cents	63.9	68.1	72.7	75.6	71.0	74.0
(SD| N)		77.4|313	77.2|127	81.9|141	93.1|150	84.9|155	91.0|134
WTP_{CP}		61.9	65.0	66.3	61.9	69.6	71.6
(SD| N)		75.3|287	74.7|146	80.9|131	73.3|164	91.4|139	87.8|153
WTP_{PP-WP}		16.8	23.3	27.5	27.2	27.7	35.0
(SD| N)		59.8|313	57.0|127	65.6|141	66.1|150	65.9|155	83.4|134
WTP_{CP-WP}		18.7	18.8	18.7	18.6	19.6	28.7
(SD| N)		59.0|287	60.0|146	68.6|131	53.1|164	79.6|139	68.3|153
		Potential Customer Sample, if $WTP_{PP,CP} >= WTP_{WP} > 0$					
WTP_{PP}	€-cents	106.2	107.6	113.1	121.5	117.0	116.4
(SD| N)		76.6|175	73.9|77	80.0|86	93.5|91	82.6|91	91.5|81
WTP_{CP}		102.2	111.8	109.8	97.2	125.5	121.7
(SD| N)		75.2|166	67.9|77	80.7|76	71.6|101	94.1|72	86.5|85
WTP_{PP-WP}		48.1	50.8	58.3	59.9	59.8	69.8
(SD| N)		56.3|175	52.2|77	61.7|86	55.9|91	65.7|91	86.3|81
WTP_{CP-WP}		47.8	52.8	54.9	41.4	67.0	64.0
(SD| N)		55.0|166	55.9|77	60.9|76	52.1|101	76.9|72	69.4|85

C = control group, Treatments: H1 = Peas/chickpeas are high in protein, H2 = Peas/chickpeas are high in fibre, E1 = The cropping of peas/chickpeas reduces CO_2-emissions, E2 = The cropping of peas/chickpeas does not require mineral fertilizer, Mix = all, PP = Green pea Pasta, CP = Chickpea Pasta, WP = Wheat Pasta, SD = standard deviation, N = observation number, $WTP_{PP,CP}$ = average willingness to pay for PP and CP, $WTP_{PP-WP,CP-WP}$ = average WTP gap between legume and wheat pasta.

4.2. The Causal Effect of Environmental and Health Claims

Describing the value of environmental and health claims to new legume products, we model the causal effect (in €-cents) a claim has on the WTP. Considering how products compete in the market place with substitutes, we model the price difference consumers pay for the legume product relative to the common substitute. To identify the claims' effect, we restrict our sample to potential customers with two basic assumptions. Firstly, potential customers must be willing to pay a price for legume pasta. Consumers choosing to Opt-Out, i.e. a zero bid, cannot become customers. Secondly, potential customers are limited to consumers who are willing to bid equal or more for the legume than for the wheat product (if $WTP_{PP, CP} >= WTP_{WP} > 0$). Estimating the effects of an econometric model can control for observed consumer characteristics in contrast to binary approaches. In accordance with prior experimental auctions [26,44], we apply a generalised Tobit regression model. Similar to these studies, the lower bound of the Tobit is set to zero and the upper bound to 5, which represents the maximum retail price observed. The cut-off at zero is only applicable for the price premium model, if the sample

can be limited to consumers whose price premium is positive or zero. The model specification includes socio-demographics and food attitudes in the Tobit. We will interpret the associations of such consumer characteristics with the WTP. The bids for wheat pasta have also been partially treated with health claims. In both models, we control for the treatment received on wheat pasta. The variability of bids may be unequal across the range of values of a second variable that predicts it, which can be of concern in experimental auctions, e.g., [26]. We use (heteroscedasticity) robust standard errors.

Looking into the causal effect of environmental and health claims, we note that claims can be expected to increase the WTP for legume pasta. Consumers who did not receive the claim tend to be unaware or do not judge the value of legume products in consideration of legume benefits. The health claims regarding fibre (H2) and regarding protein (H1) achieve consistently over two products a higher WTP than the control group. The effect varies between 3 and 12 cents (Table 4), while the fibre claim appears superior to the protein claim, but both claims fail to achieve an effect at standard significance levels. The environmental claims on CO_2-emissions (E1) and fertiliser (E2) achieve effect magnitudes at least comparable to the fibre claim. Again, a significant effect cannot be confirmed in both models. Most convincingly, the mix of all claims achieves a consistent and significant effect on WTP. The average effect size varies between 19 and 22 cents (Table 4). The effect may not double the effect of any individual claims, but reveals that a mix of health and environmental claims is most successful with potential customers.

Table 4 Claims' and food attitudes' marginal effect on the potential customers.

Tobit		Green pea Pasta (PP) $WTP_{PP\text{-}WP}$		Chickpea pasta (CP) $WTP_{CP\text{-}WP}$	
Variables	Scaling Direction	ME	SE	ME	SE
H1	Treatment Vs. Control Group	9.4	8.5	4.9	9.3
H2		13.9	9.1	10.3	9.7
E1		14.9*	8.6	−6.6	8.1
E2		12.4	9.5	16.5	11.0
Mix		21.4*	12.5	21.6**	9.4
Price [std]	-> less price sensitive	6.0*	3.3	6.0*	3.6
Health [std]	-> less concern for health	−4.6	3.5	−8.7**	3.4
Visual [std]	-> less attracted to visual	−11.2***	3.4	−4.3	3.3
Social [std]	-> disagrees with social barrier	2.2	3.4	8.4***	3.1
Flatulence [std]	-> disagrees with flatulence issue	5.5*	3.1	9.6***	3.3
Gender [0,1]	-> women	11.3*	6.1	16.9***	6.3
Age [years]	-> older	−0.1	0.3	−0.5**	0.2
Income [std]	-> higher income	5.7*	3.2	0.6	1.4
Education [std]	-> higher education	−1.8	3.3	2.8	4.2
N		582		563	
Prob > chi²		0.001		0.000	

$WTP_{PP,CP\text{-}WP}$ = WTP gap between legume and wheat pasta, ME=marginal effects (outcome in €-cents), SE = heteroscedasticity robust standard error of regression coefficient, Significant levels *=10%, ** = 5%, *** = 1%, H1 = Peas/chickpeas are high in protein, H2 = Peas/chickpeas are high in fibre, E1 = The cropping of peas/chickpeas reduces CO_2-emissions, E2 = The cropping of peas/chickpeas does not require mineral fertilizer, Mix = H1 + H2 + E1 + E2.

4.3. Food Attitudes Relationship with WTP

Most control variables are standardised so that their coefficients can be compared. The magnitude can be interpreted as a change in WTP associated with a change by one standard deviation of the independent variable. Unsurprisingly, among potential customers the WTP is still heterogeneous. Several food attitudes are significantly linked with a higher WTP, however, the link may vary depending on whether chickpeas or green peas are evaluated. While the direction of the link is predominantly the same for both products, the strength of the link can vary. A higher concern for health in eating habits or social barriers to legumes is a significant factor for the purchase of CP and not for PP (Table 4). Similarly, being visually attracted to the product appears to be more important with the green PP than the yellow/orange CP (Table 4). To consider oneself price sensitive is equally linked to PP and CP. Flatulence reservations can matter with both products. Further, women can be linked to higher bids. Younger consumers bid more for the chickpea product than older ones, and higher income consumers can be associated with higher bids for the green pea product.

5. Discussion

Researchers (and marketers) need to think about the aspects of the products that are most appealing to consumers [12]. Legumes offer various health and environmental benefits that we have discussed. Claims regarding such benefits may optimise behaviour due to a demand increase for healthier and environmentally friendlier products. The short information provided in a claim is a low-cost opportunity to encourage purchase and to spread knowledge on legumes. Estimating the potential of claims on new legume products, we show the causal effect of four claims on the WTP for green pea (PP) and chickpea pasta (CP). The health claims concern the high protein (H1) and high fibre (H2) content of the products. The environmental claims, which are not applied in practice for any legume product, deal with CO_2-emissions and fertilisers. The tested claims for legumes are founded on, to our knowledge, unchallenged evidence. The claims are formulated on a legume type basis and can be used interchangeably for many legume products.

We discuss the findings on WTP for legumes relative to wheat pasta. The claims increase the WTP for legume pasta. The effect size is heterogeneous with high standard deviation, so that individual claims predominantly fail to achieve standard significance levels. The results do not imply that the admitted health claims are superior to environmental claims, although acting on environmental claims is motivated by altruistic instead of personal motives. Building on the individual claims, the results reveal that a combination of the health and environmental benefits is most successful and increases the average WTP of potential customers by about 20 cents. The combination of personal health and interpersonal environmental benefits helps consumers to justify a higher price and possibly the switching to a new product.

Environmental benefits are impersonal and delayed, so it is often hypothesised that consumers only pay a price premium if the environmental benefits are connected to private ones [12,20]. Indeed, labelling studies on organic products, which claim environmentally friendlier production, have observed a mix of effective purchase drivers. They have reported quality and health criteria as decisive drivers rather than environmental concerns [45]. The recent study by Becker et al. [45] contradicted the health role in organic purchases. It identified environmental awareness as a primary driver of organic purchases. While a mix of environmental and health messages remains the most recommendable

option, the findings of Becker et al. [45] imply an increasing demand for environmental messages in marketing.

Claims on CO_2 emissions are known as voluntary options for food processors. It is argued that carbon labelling enables consumers to make greener choices if the labels are mandatory to allow fair comparisons between products and product categories [30]. Prior studies approximate the amount of consumers interested in carbon labelling. The findings from Germany and Canada suggest that about one-fifth of consumers are ready to consider carbon information in their food choice [31]. A cluster of about one-third of UK consumers was found to show concern for sustainability and was interested in carbon labelling [30]. A message on pesticide use, framing environmental issues, respectively, has been found to be more effective than health messages on polyphenols with respect to apple purchases [34]. However, pesticide or fertiliser use may unwillingly send a health message to consumers. Independent of the rightfulness of health worries regarding fertilisers and residues, claiming the absence of fertiliser may create an additional health message that contributes to the effect on WTP.

The effect size of a claim relative to a no-claim situation is difficult to compare to earlier studies, because we apply an online design focusing on potential customers who represent about 56 to 59% of the full sample. The full sample mimics a cross-section of German consumers with quotas for gender, age, and income. The online auction allowed for the quoted recruitment process and the exclusion of the usual financial endowments. The online auction is a singularity of this study and needs to be validated in further applications. It depends on the perception of visuals. Evaluations by product visuals are found to produce equally credible WTP measures in comparison with including tactile or olfactorial factors in the mix [26]. A taste opportunity does not resemble a retail setting. However, a visual setting of unknown products resembles first purchases, but does not account for repeated purchases, which build on experiences rather than expectations. Sensory studies that allow consumers to taste the product tend to produce higher WTP estimates [39].

This online auction produced mean WTP measures for wheat pasta that closely resemble the retail prices and a mean WTP for the newly introduced legume pasta that falls short of the current retail prices, which only a minority is willing to pay. The observed retail prices cannot be justified by the higher costs for raw materials. Producers may use a price skimming strategy, whereas marketers set a relatively high initial price for a product or service at first, then lower the price over time. Noteworthy, a relatively high percentage (35 to 37%) of the consumers were not willing to place a bid. The high percentage might be explained by features of the online setting or the absence of a direct financial endowment. Further mimicking a marketplace and increasing the external validity of samples, possibly by building on the online auction approach, will offer a reliable idea of consumers' decisions to buy healthier and greener products.

Looking into consumer characteristics, we find significant links, although the findings are not necessarily the same for green pea and chickpea pasta. Klemcke et al. [5] found that legumes are generally accepted to be healthy, and negative associations, such as flatulence, are of lesser importance to market legumes. We contradict the findings in a way, as potential customers, who perceive flatulence critical, have a significantly lower WTP for legume products. The healthfulness perception of legumes may also differ between green peas and chickpeas. We find potential customers' concern for health in eating habits to be associated with a higher WTP for chickpea but not for green pea pasta. The health concerns have been linked to choices for the supposedly healthier option over the classic alternative [39]. This implies that customers' perception of chickpeas is linked to a healthy food image,

while green peas are not. The rising interest in health and diet links [39] suggests an increasing worth of such a food image. Social barriers point also to a different image between legume crops, because the chickpea product is affected by the factor on statements such as "consumed only by organic consumers", while green peas WTP cannot be linked to these perceptions. The visual attraction to a product has been found to significantly enhance consumption [40]. Again, the visual attraction mattered to the green pea pasta, while the yellow to orange colour of chickpea pasta, which is closer to the wheat version, could not be linked to WTP. Processors of new legume products may want to consider distinguishing the visual design of their product from the substitutes in order to increase the initial interest.

Analysing a wide range of socio-demographics, Togler and Garcia-Valiñas [46] find women and financially satisfied people to reveal stronger preferences for environmental protection. Less consistent tendencies indicate that younger and higher educated people reveal the same preferences. Women have also been linked to a higher WTP for products with health functions [39]. We find women to have a higher WTP for the legume products than men. The finding may or may not be based on stronger perceptions by women with respect to legumes being healthy and environmentally friendly. Lastly the WTP for chickpea pasta is higher with younger consumers if income is controlled for in the model. Therefore chickpea pasta may develop into a trendy product. The food attitudes and socio-demographic characteristics are linked to WTP, but are not necessarily a causal driver to WTP. We cannot exclude the possibility that a latent variable, not controlled for in the model, is the causal driver to WTP and correlated with a characteristic.

Reflecting on the current legislative framework for environmental claims, we want to note the trade-off between strict and lax regulations. Restrictive regulation is often regarded as favourable for consumer protection [14]. Stricter regulation of claims will surely build trust in claims and prevent unsubstantiated marketing. The drawback is the constraint of valid product benefits due to costly or time-intensive admission processes. For legumes, we observe that only soy beans, the most widely commercialized legume crop, has admitted health utility claims with the US Food & Drug Administration (FDA). Soy processors may claim a reduced risk of heart diseases due to soy consumption [13]. The benefit is unlikely to be limited to soy. The introduction of health claim regulation provides the opportunity to research the trade-off between economic barriers of admission and trust in claims.

Lastly, the flatulence concern that restricts consumers' WTP for legumes could be tackled with research from public or private initiatives. A few breeding programmes have deviated from the classic success parameters in the field and incorporated taste and digestibility. Nevertheless, we are only aware of programmes acting in such a way for high-value crops such as wheat. These breeding efforts would be well received to encourage demand on legumes. The marketing of legumes is not restricted to the environmental benefits of CO_2-emission and fertiliser savings. Other benefits and different marketing strategies to communicate benefits are plausible. Additional environmental benefits may include marketing the increased agricultural biodiversity with mixed legume cropping schemes [47] or legumes' contribution to a rooting system that improves soil properties.

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Dominic Lemken, Mandy Knigge—Statistical analysis: Dominic Lemken—Collection and preparation of data: Dominic Lemken, Mandy Knigge—Interpretation of statistical analysis: Dominic Lemken, Drafting Manuscript: Dominic Lemken, Editing manuscript: Achim Spiller, Stephan Meyerding

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1 Socio-demographics and food attitudes by treatment.

Treatment	Total		C	E2	E1	H1	H2	Mix		C	E2	E1	H1	H2	Mix	
			Chickpea pasta							Green Pea pasta						
N			288	141	165	146	131	153	Prob > F	313	155	150	127	141	134	Prob
Variables [Min-Max]	Ø	SD	Ø	△Ø	△Ø	△Ø	△Ø	△Ø		Ø	△Ø	△Ø	△Ø	△Ø	△Ø	> F
Gender [0–1]	0.50	0.50	0.50	–0.06	0.05	0.03	0.03	–0.06	0.22	0.48	–0.06	–0.01	–0.01	0.02	–0.07	0.54
age [19–86]	46.78	14.71	46.98	0.24	1.03	−0.96	–0.10	1.00	0.85	47.13	–0.26	2.16	1.69	–0.59	–0.47	0.45
Income [1–9]	4.80	2.15	4.92	–0.21	0.34	0.25	0.16	0.23	0.23	4.82	–0.11	–0.20	0.01	0.17	0.32	0.36
Education [1–4]	3.32	0.75	3.34	–0.09	0.04	0.11	0.07	–0.03	0.29	3.27	–0.03	–0.15	–0.10	–0.08	–0.03	0.42
Price [–1.2,3.2]	0.00	1.00	–0.03	–0.06	–0.04	–0.07	–0.06	–0.01	0.97	–0.03	–0.12	–0.01	–0.09	–0.01	0.02	0.80
Health [–1.6,3.7]	0.00	1.00	–0.05	0.01	0.00	-0.28	–0.04	–0.05	0.08	–0.06	–0.13	–0.09	–0.18	–0.03	–0.02	0.55
Visual [–1.3,3.4]	0.00	1.00	–0.05	0.04	–0.19	–0.04	–0.05	–0.10	0.38	–0.02	0.01	–0.08	–0.07	–0.02	–0.02	0.95
Social [–4.6,0.9]	0.00	1.00	0.00	–0.07	–0.02	–0.00	0.07	0.05	0.88	0.03	0.09	–0.01	0.28	–0.06	–0.06	0.051
Flatulence [–1.6,1.8]	0.00	1.00	0.00	0.00	0.01	0.03	–0.00	–0.02	0.99	–0.02	–0.05	–0.10	0.01	0.07	–0.04	0.78

H1 = Peas/chickpeas are high in protein, H2 = Peas/chickpeas are high in fibre, E1 = The cropping of peas/chickpeas reduces CO_2-emissions, E2 = The cropping of peas/chickpeas does not require mineral fertilizer, Mix = H1 + H2 + E1 + E2, The Anova (p-value = prob > F) cannot reject the hypothesis of no significant differences between treatments at the 5%-level for all variables. Gender is based on the Kruskal-Wallis-Test. △Ø = control mean–treatment mean.

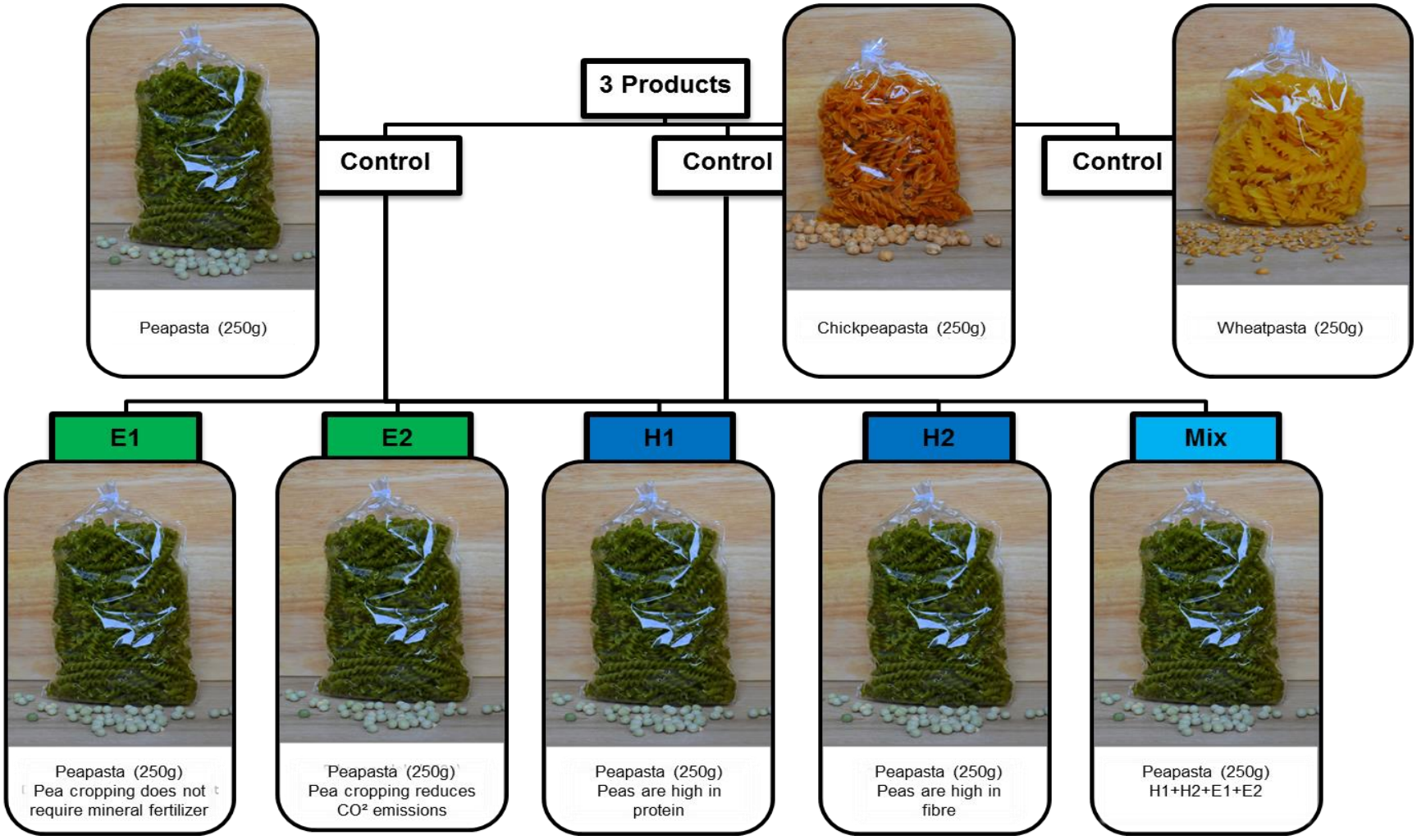

Figure A1 Design of product visuals and claims between treatments

(Note: treatments exemplified for pea pasta, experimental design translated from German).

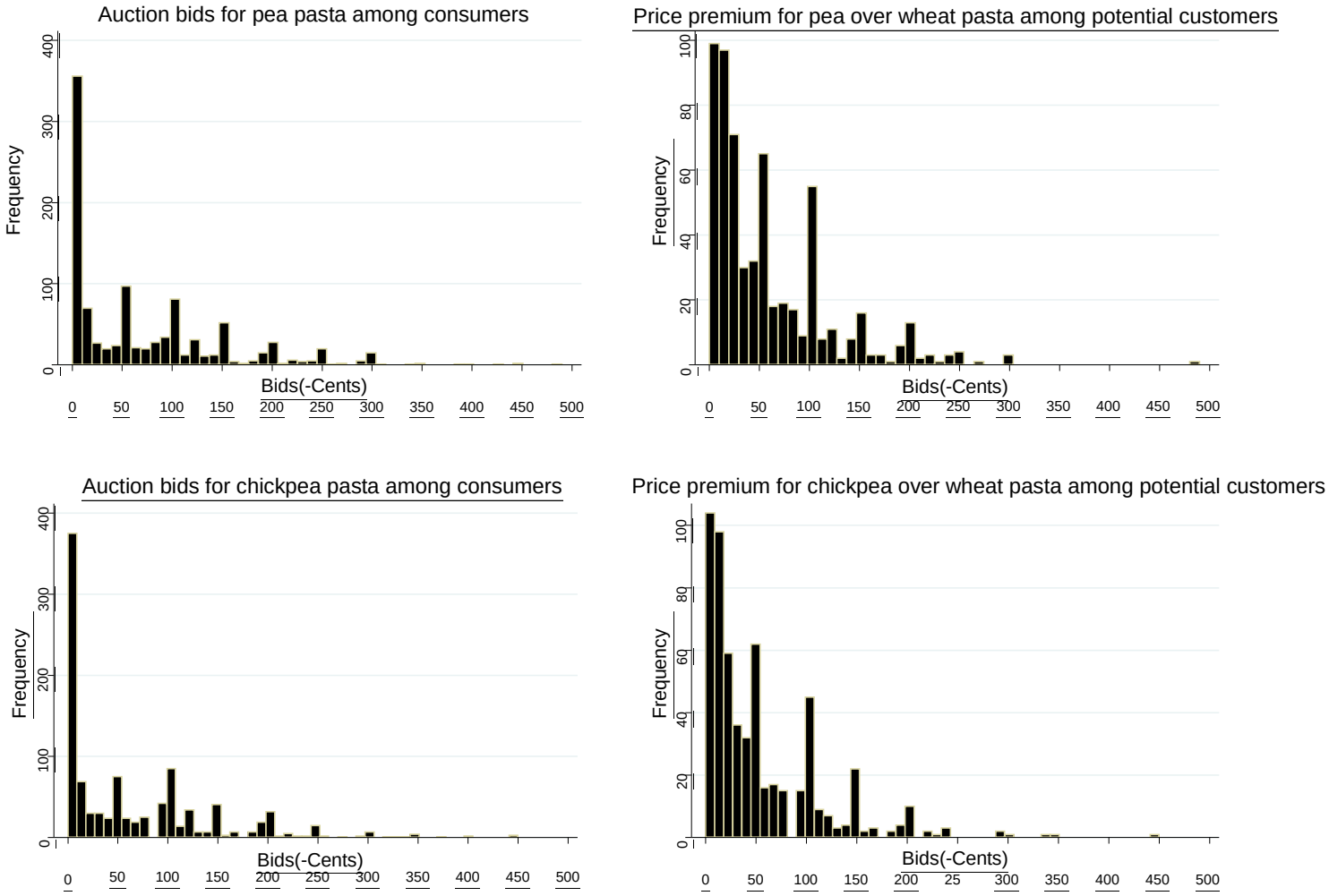

Figure A2 Distribution of bid estimates for legume pasta

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Excursus 1: Welche Faktoren beeinflussen den Roggeneinsatz in der Schweinefütterung?

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Zusammenfassung:

Der Roggenanbau ist besonders auf leichten Böden verbreitet. Durch klimatische Veränderungen und eine zukünftig stärkere Reglementierung der Düngung wird er zunehmend auch auf besseren Standorten ökonomisch relevant. Im Vergleich zu Weizen benötigt der Roggen weniger Nährstoffe, nicht zuletzt Stickstoff, um adäquate Erträge zu erzielen. Damit eine Erweiterung des Roggenanbaus ökonomisch attraktiver wird, müssen die Absatzwege ausgebaut werden. Dafür bietet die Schweinefütterung noch erhebliches Potenzial. Roggen spielt als Energiekomponente in der Schweinefütterung trotz ökonomischer Vorteile gegenüber Weizen, noch immer eine untergeordnete Rolle. Die folgende Arbeit untersucht, welche Faktoren den Roggeneinsatz und die Höhe der Roggeneinsatzmenge in der Schweinefütterung beeinflussen. Die Ergebnisse einer Umfrage unter Schweinehaltern in Deutschland weisen persönliche, externe/soziale und betriebsinterne Faktoren auf. Ein zweistufiges ökonometrisches Modell erlaubt dabei eine getrennte Betrachtung der Faktoren, die im Zusammenhang mit der Roggeneinsatzmenge stehen und jener Faktoren, die mit gänzlichem Verzicht auf Roggen in der Fütterung in Verbindung gebracht werden können. Bei persönlichen Einstellungen zeigt sich, dass die negativere Einschätzung von Roggenvermeidern bereits beim Anbau beginnt. Bei betriebsinternen Faktoren sticht der Roggenanbau auf dem eigenen Betrieb hervor. Informationskampagnen sollten sich bei der Roggenvermarktung stets auf Anbau und Fütterung beziehen. Betriebe, die ihr Futter selber mischen, verwenden signifikant höhere Roggenmengen in den Futterrationen, wobei der Einkauf von Fertigmischung tendenziell häufiger zu Roggenanteilen im Futter führt. Wir diskutieren die Roggeneinsatzfaktoren im Hinblick auf Implikationen für das Marketing und die Praxis. Die Ergebnisse legen auch interessante Anschlussstudien nahe zu der Futtermittelzusammensetzung in Mischfutterwerken oder einer getrennten Analyse der Sauen, Ferkel und Mastschweinehaltung.

Schlüsselwörter: Schweinefütterung, Getreide, Entscheidungsverhalten, zweistufiges Modell für landwirtschaftliche Verbrauchsgüter

Abstract

Rye cultivation is particularly diffused on light soils. Due to climatic changes and stricter regulations on mineral fertilization, rye production will become more economically viable on good soils. Compared to other cereals, rye needs fewer nutrients, e.g. nitrogen, to achieve satisfactory yields. For an expansion of the cultivation of rye, sufficient sales channel are needed to ensure economic attractiveness. Pig feeding is a relevant option but underutilized. Rye plays a minor role as a cereal component in pig feeding, despite economic advantages which are demonstrated relative to wheat. The following study examines the factors that influence the use of rye and the quantitative amount of rye used in pig feeding. The results of a survey among pig holders in Germany examine personal, external/social and farm related factors, respectively. The application of a double hurdle model allows for an individual analysis of factors related to the amount of rye used and factors related to a renunciation of rye in pig feeding. Personal attitudes towards rye are more negative with farmers who avoid rye, not just related to feeding, but also related to cropping. On farm rye cultivation stands out among all factors to influence rye adoption. Conclusively, information campaigns should focus on both, cultivation and feeding. A combined communication of the potential problem of ergotism and the low Fusarium susceptibility may improve the perception of rye as feeding component. Self-mixing of feeding materials is positively related to the quantity of rye used. In contrast users of pre-mixed feeding materials have more often rye in the mix. We discuss the factors of feeding in order to guide marketing and practical agriculture, respectively. The results suggest interesting follow up studies on feed mixes in compound feed plants or a distinguished analysis of sow, piglet and rearing pig farms.

Keywords: pig fodder, cereals, adoption behavior, double hurdle model for commodity marketing

1. Einleitung

Roggen ist als Futtermittel ein landwirtschaftliches Verbrauchsgut, welches direkt in das hergestellte Produkt eingeht (MUßHOFF und HIRSCHAUER, 2011). Deutschland ist mit 3.854.400 t im Jahr 2014 das Land mit der größten Roggenproduktionsmenge weltweit (FAO, 2016). Der Roggen wird in Deutschland hauptsächlich für die Humanernährung und die Nutztierfütterung verwendet. Dabei sind die Absatzmengen für die menschliche Ernährung zwischen 786.000 t und 900.000 t in den Jahren 2004 bis 2012 relativ konstant, wohingegen die Mengen für die Fütterung zwischen 713.000 t und 1.435.000 t im selben Zeitraum stärker schwanken (VDM, 2013). Aus pflanzenbaulicher Sicht bietet der Anbau von Roggen gerade auf leichteren Standorten mit geringer Wasserverfügbarkeit seine Vorteile. Im Hinblick auf die Novellierung der Düngeverordnung (BUNDESMINISTERIUM FÜR ERNÄHRUNG UND LANDWIRTSCHAFT, 2015) sowie die klimatischen Veränderungen kann der Roggenanbau in Zukunft aber auch auf besseren Standorten interessant werden. Er benötigt eine geringere Nährstoffversorgung als andere Getreidearten, um hohe Erträge zu erzielen (LIEBEREI et al., 2012). Um Anpassungen an die Düngeverordnung zu leisten, ist Roggen gerade für Ackerbaubetriebe eine interessante Kultur um Stickstoff einzusparen (THIEMT, 2007). Die Bedarfsempfehlungen beim Stickstoffdünger liegen dabei rund 25-35 % niedriger als bei Weizen und einigen anderen Getreidearten (LWK, 2010). Um eine Ausweitung des Roggenanbaus zu unterstützen, müssen jedoch entsprechende Absatzmöglichkeiten vorhanden sein. Grundsätzlich hat der Roggen als Futtergetreide aktuell eine vergleichsweise

untergeordnete Bedeutung in der Nutztierfütterung. Im Wirtschaftsjahr 2014/2015 lag der durchschnittliche Roggenanteil in Mischfuttermitteln bei nur sechs Prozent, Weizen hingegen machte einen Anteil von 19 % aus (DVT, 2015), obwohl Futterroggen in den vergangenen sechs Jahren im Durchschnitt 2,75 €/dt günstiger war als der Futterweizen (AMI, 2016). In Deutschland legen die Tierzahlen in der Schweinehaltung sowie die Preise für Futtermittel nahe, dass in eben diesem landwirtschaftlichen Betriebszweig ein Ausbau des Roggeneinsatzes die Absatzchancen des Roggens merkbar verbessern würde. Ziel ist es, mit Hilfe einer Studie zu untersuchen, welche Faktoren den Einsatz von Roggen in der Schweinefütterung beeinflussen, um differenzierte Potenziale bei Schweinehaltern aufzuzeigen. Die Potenziale sollen die Diffusion von Roggen als Futtermittel in der Schweinehaltung erleichtern.

In der Folge werden zunächst die Fütterungseigenschaften erläutert und die Basisannahme der ökonomischen Vorzüglichkeit des Roggens gegenüber dem Weizen belegt. Anschließend werden die untersuchten Faktoren und das methodische Vorgehen der Studie vorgestellt. Die empirischen Ergebnisse werden getrennt von der Diskussion dargestellt. Das Fazit beinhaltet Implikationen und Limitationen der Studie.

2. Roggen in der Schweinefütterung

Der Rohproteinanteil der Trockensubstanz im Roggen beträgt ca. zehn Prozent und ist mit zwei bis fünf Prozent niedriger als der Rohproteingehalt von Gerste, Weizen und Triticale (GAGERN, 2007). Die essentiellen Aminosäuren Methionin und Zystin sind in einem etwas geringeren Maße im Roggen vorhanden als in anderen Getreidearten. Der Lysin-Gehalt des Roggens hingegen ist höher als bei Weizen (LWK, 2012). Der Anteil an mehrfach ungesättigten Fettsäuren im Roggen wirkt sich positiv auf die Fettbeschaffenheit des Fleisches aus (ALERT und FRÖHLICH, 2006). Aus älteren Beobachtungen geht hervor, dass der Roggeneinsatz in der Schweinefütterung eine Reduzierung der Futteraufnahme sowie eine Verschlechterung des allgemeinen Zustandes der Tiere hervorrufen kann (MEYER et al., 2006). Andere Ergebnisse zeigen jedoch, dass auch höhere Roggenanteile von bis zu 70 % der Fütterungsration nicht zu Leistungseinbußen der Tiere führen. Außerdem konnten frühere Problembestandteile des Roggenfutters wie Bitterstoffe und Mutterkorn durch die Züchtung reduziert werden (MEYER et al., 2003; WEBER et al., 2004; WEBER, 2012; MEYER, 2013). Begrenzend für den Roggeneinsatz in der Jungtierfütterung ist der relativ hohe Anteil von Nichtstärkepolysacchariden (NSP) wie z.B. Pentosanen. Zu hohe Roggenanteile in der Ration können dort zu Leistungseinbußen führen. Bitterstoffe und Alkylresorcinole, die zu einer geringeren Futteraufnahme führen, sind in modernen Roggensorten aber nur noch in einem geringeren Maße vorhanden (GAGERN, 2007). Die Mykotoxinbelastung von Roggen stellt sich zwiegespalten dar. Auf der einen Seite ist er weniger anfällig gegenüber Fusarium als Weizen, auf der anderen Seite ist die Mutterkornanfälligkeit *(Claviceps Popurea*) beim Roggen im Vergleich zu anderen Getreidearten am stärksten ausgeprägt (MEYER, 2013).

Ein entscheidender Faktor beim Einsatz von Roggen in der Schweinfütterung ist die Menge in der Ration. Aus diversen Fütterungsversuchen geht hervor, dass ein hoher Roggenanteil von teilweise über 50 % in der Gesamtration vergleichbare Zunahmen lieferte, wie die Kontrollgruppe ohne Roggeneinsatz (WEBER, 2012). Bereits bei einer Lebendmasse von 12 kg je Ferkel ist der Einsatz von 15 % Roggen in der Futterration und bei einem Mastschwein von bis zu 70 % ohne Leistungseinbußen umsetzbar (ALERT und FRÖHLICH 2006); MEYER et al. 2003). Zum maximalen Einsatz von Roggen in der

Schweinefütterung hat die Deutsche Landwirtschaftsgesellschaft (DLG) e.V. Empfehlungen veröffentlicht (Tabelle 1). Diese gelten unter der Bedingung, dass die Aminosäureversorgung durch andere Futterkomponenten bedarfsgerecht ausgeglichen wird (MEYER et al., 2006).

Tabelle 1 DLG Einsatzempfehlung Roggenfütterung

	Empfehlungen	Ø Stichprobe (N)[1]
28-40 kg Lebendgewicht (LG) (Vormast)	30 %	7,2 (81)
40-60 kg LG (Anfangsmast)	40 %	12,5 (81)
60-90 kg LG (Mittelmast)	50 %	
ab 90 kg LG (Endmast)	50 %	16,9 (81)
Sauen	25 %	1 % (24)
Ferkel bis 15 kg LG	10 %	1,7 % (31)
Ferkel ab 15 kg LG	20 %	4,0 % (31)

Quelle: Die Empfehlungen beruhen auf MEYER et al. (2006), [1]Vorgriff auf durchschnittlichen Roggeneinsatz der Betriebszweige in der vorliegenden Studie

Neben diesen ernährungsphysiologischen Eigenschaften spielt der Preis des Roggens im Vergleich zu stärker eingesetzten Substituten wie Weizen eine bedeutende Rolle für die Futtermittelauswahl. WEBER (2012) kommt zu dem Ergebnis, dass Roggen 0,50 € -1,00 €/dt preiswerter sein muss als Weizen, damit er ökonomisch vorzüglich wird. Dabei wird der minimal geringere Eiweißgehalt des Roggens berücksichtigt, der durch einen höheren Anteil von teureren Eiweißfuttermitteln wie z.B. Sojaschrot ausgeglichen werden muss. Nach Daten von BAUER (2016) sind Erzeugerpreise für Brot- und Futterroggen im Gebiet der ehemaligen Landwirtschaftskammer Hannover im Zeitraum von 2004/2005 - 2014/2015 durchschnittlich 1,02 € bis 2,04 €/dt günstiger als Futterweizen. Im bundesdeutschen Durchschnitt war der Roggen zwischen 06/2010 und 09/2016 durchschnittlich ca. 2,75 € / dt günstiger. Dabei lag die Preisdifferenz von Futterroggen und Futterweizen in 96% aller Wochen über einem Euro und in immerhin noch 67 % aller Wochen sogar über 2 Euro (AMI, 2016). Ausgehend von der Preisdifferenz zum Weizen zeigt sich, dass der Energienachteil zum Weizen von 0,3 MJ/kg (LWK 2012) durch den Preisunterschied kompensiert wird. So liegt der Roggen zwischen 06/2010 und 09/2016 bei ca. 1,11 €/MJ während der Weizen bei ca. 1,29 €/MJ liegt (LWK 2012; AMI, 2016).

Somit ist der Futterroggen dem Futterweizen über den Zeitraum der letzten sechs Jahren ökonomisch vorzüglich. Abschließend kann festgestellt werden, dass aus wissenschaftlicher Sicht der Fütterung von Roggen in der Schweinehaltung sowohl ernährungsphysiologisch als auch aus ökonomischer Sicht nichts entgegen spricht.

3. Landwirtschaftliches Entscheidungsverhalten und Untersuchungsfaktoren beim Roggeneinsatz

Die Entscheidung zur Verwendung eines bestimmten Futtermittels kann kurzfristig variiert werden. Nach ZIMMERMANN (2003) herrscht an Verbrauchsgütermärkten ein harter Preiswettkampf, da die Produkte wenig differenziert sind. In unserem Beispiel bedeutet das, dass Roggen nicht nur durch Roggen aus anderen Chargen, sondern auch durch andere Energieträger wie z.B. Weizen, Gerste oder Mais substituiert werden kann (ibid). Die Entscheidungsbildung für ein bestimmtes Produkt wird durch verschiedene ökonomische, psychologische und soziologische Modelle erklärt. Psychologische

Modelle fokussieren sich auf Motive und Einstellungen, während in der Soziologie der Einfluss des sozialen Umfelds auf den Käufer im Mittelpunkt steht (KROEBER-RIEL und GRÖPPEL-KLEIN, 2013). Um das reale Verhalten abzubilden, ist ein interdisziplinärer Ansatz von Nöten (ZIMMERMANN, 2003).

Verschiedene Studien haben das landwirtschaftliche Entscheidungsverhalten beleuchtet. WILLOCK et al. (1999) haben für eine Befragung von Agrar-Stakeholdern ein Modell zur landwirtschaftlichen Entscheidungsfindung entwickelt, welches auf AJZEN (1985) „Theory of Planned Behavior" aufbaut. Dieses Modell wurde später aufgegriffen (GRANOSZEWSKI et al., 2009), um das Investitionsverhalten von Landwirten in Erneuerbare Energien zu untersuchen. Bei den Modellen kommen die grundsätzlichen entscheidungsbeeinflussenden Faktoren aus drei Bereichen: 1. Persönliche Faktoren, welche verschiedenste Einstellungen zur jeweiligen Entscheidung umfassen, 2. Externe Faktoren, welche das geographische und soziale Umfeld berücksichtigen, 3. Betriebsinterne Faktoren, wobei Eigenschaften der spezifischen Betriebsstruktur im Vordergrund stehen. Diese Untersuchung hat das Ziel Faktoren für den Roggeneinsatz in der Schweinefütterung zu bestimmen und wird dabei auf die oben genannten drei Faktoren zurückgreifen.

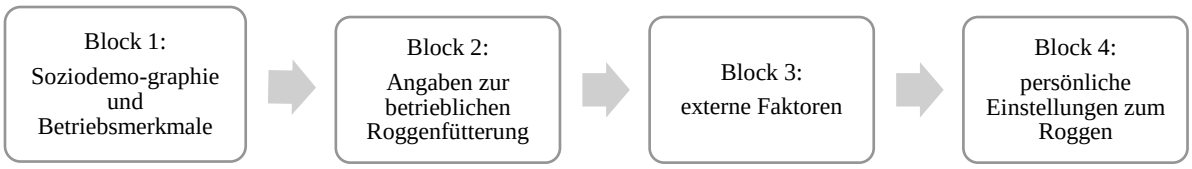
Das Kaufverhalten von Landwirten, bezogen auf landwirtschaftliche Investitionsgüter, ähnelt weder Konsumenten noch organisationalen Nachfragern (ZIMMERMANN, 2003). Landwirte entscheiden ähnlich wie Konsumenten unter Einfluss ihres sozialen Umfelds, nutzen jedoch ähnliche Informationsquellen wie industrielle Unternehmen. Beim sozialen Umfeld spielt das geographische Umfeld und das soziale Netzwerk eine Rolle in der Entscheidungsbildung (SOLANO et al., 2003). In Bezug auf den Einsatz von Roggen in der Schweinefütterung wird daher vermutet, dass auch hier die positive Bewertung von Roggen durch das Umfeld des Schweinehalters den Einsatz als Futterkomponente in der Schweinefütterung beeinflusst. Gerade auf leichten Standorten ist der Roggen gegenüber Weizen vorzüglich (MIEDANER, 2013). Es wird davon ausgegangen, dass Betriebe die einen hohen Roggenanteil in der Fruchtfolge haben, auch mehr Roggen in der Fütterung einsetzen, da der Roggen bereits im Betrieb vorhanden ist.

Ein weiterer Faktor bei der Entscheidungsfindung über den Einsatz von Futterrogen kann die Durchführung der Futterzubereitung sein. Unterschieden wird zwischen den Landwirten, die ihr Futter selber mischen und jenen Betrieben, die Fertigfutter von einem Mischfutterwerk zu kaufen. Aufgrund der Flexibilität der Eigenmischer wird davon ausgegangen, dass Landwirte, die ihr Futter selber mischen, vermehrt Roggen als Futterkomponente einsetzen. Einen Einfluss auf den Einsatz von Futterroggen in der Schweinefütterung könnte der Betriebsschwerpunkt haben. Spezialisierte Betriebe kalkulieren häufig intensiver (LÜPPING und SCHAPER, 2009). Deshalb wird davon ausgegangen, dass Betriebe, die ihren Schwerpunkt in der Schweinehaltung sehen, häufiger den ökonomischen Vorteil des Roggens nutzen. Eine höhere Tierzahl auf dem Betrieb kann im Hinblick auf Einkaufsmengen zu einer besseren Übersicht auf dem Beschaffungsmarkt führen. Es wird vermutet, dass Betriebe mit großen Tierzahlen vermehrt Roggen als Futtergetreide einsetzen. Zusätzlich sollen noch umfassend subjektive Einstellungen zu anbau- und ernährungsphysiologischen Eigenschaften des Roggens erhoben werden, um jene Bereiche zu identifizieren, die eine Barriere beim Einsatz darstellen.

4. Studiendesign

Die Umfrage zum Roggeneinsatz in der Schweinefütterung wurde von Dezember 2015 bis Januar 2016 mit deutschen Schweinehaltern durchgeführt. Dazu wurde ein online-gestützter digitaler Fragebogen entwickelt, der in der Folge genauer erläutert wird. Aufgrund zeitlicher und finanzieller Restriktionen war eine repräsentative Umfrage nicht möglich. Die Verbreitung der Umfrage erfolgte über Verbände wie die Interessengemeinschaft der Schweinehalter Deutschlands e.V. (ISN) und den Verein zur Förderung der bäuerlichen Veredlungswirtschaft GmbH (VzF). Der Fragebogen wurde als Fütterungsthema beworben. Die Teilnahme war freiwillig.

Abbildung 1 Aufbau des Fragebogens



Der Fragebogen gliedert die Untersuchungsfaktoren betriebliche, externe und persönliche Faktoren, in drei Frageblöcke (Abbildung 1). In Block 2 wurde der Roggenanteil an den Futterrationen in den verschiedenen Betriebszweigen der Schweinehalter erfasst. Anhand eines ökonometrischen Modells, welches den Zusammenhang in Abhängigkeit von übrigen Faktoren prüft, soll der Roggeneinsatz erklärt werden. Da einzelne Betriebszweige nur begrenzt in der Stichprobe vertreten waren, soll eine gemeinsame Analyse der Schweinehalter, die unterschiedliche Sensibilität der Tiere berücksichtigen. Der Roggenanteil variiert dabei erheblich zwischen Sauen, Ferkeln und Mastschweinen. Eine Zusammenfassung der Haltungszweige erfordert daher eine vergleichbare Variable. Der Roggeneinsatz der Probanden wurde daher im relativen Verhältnis zur max. DLG-Empfehlung (Tabelle 1) gesetzt, um eine Art verbleibende Roggeneinsatzkapazität für die Betriebe darzustellen. In die Variable fließen die Angaben der Probanden zu ihrer aktuellen Roggenfütterung in der Vormast, der Mittelmast, der Endmast, bei den tragenden Sauen, in der Ferkelhaltung bis 15 kg und Ferkelhaltung ab 15 kg ein. Die Höhe des Roggenanteils in der Fütterung wurde durch eine Skala abgefragt, auf der 0-100 % Fütterungsanteil ausgewählt werden konnten. Dann wurden diese Angaben mit den entsprechenden Werten aus der DLG-Empfehlung ins Verhältnis gesetzt und zusammengefasst. Dies bildet die Untersuchungsvariable, um entscheidende Einflussfaktoren zu identifizieren. Ein untersuchter externer Faktor „Bewertung des Umfelds“ basiert auf der Frage, „Wie bewerten die Personen, deren Meinung Ihnen am wichtigsten ist, die Eignung des Roggens als Getreidekomponente im Futter?“. Der untersuchte Faktor „Roggenanbaugebiet“ bezieht sich auf die Region, in welcher der Betrieb angesiedelt ist. Um den Anteil des Roggenanbaus in der Region des Betriebs zu ermitteln, wurde eine Variable entwickelt, welche die ersten beiden Ziffern der Postleitzahl mit regionalen Roggenanbau-Erhebungen (STATISTISCHES BUNDESAMT, 2012) abgleicht. Die Einteilung erfolgt in sechs Intensitätsstufen. Die betriebsinternen Variablen wurden ebenfalls erhoben: die Tierzahl in absoluten Zahlen, Roggenanbau auf dem eigenen Betrieb entspricht dem prozentualen Anteil an den Fruchtfolgen, Schweineschwerpunkt und Selbstmischer-Eigenschaften wurden binär erfasst.

Im vierten Block des Fragebogens wurden die Probanden zur ihrer persönlichen Einstellung zum Roggen befragt, aufgrund der Bedeutung subjektiver Einstellungen in der landwirtschaftlichen Entscheidungsfindung (ZIMMERMANN, 2003). Es wurden verschiedene Einstellungen durch eine Statement-Batterie ermittelt, in der die Probanden positive und negative Aussagen über die Eignung des Roggens in der Schweinefütterung bewerten mussten. Die Statements basieren auf gesammelten Bedenken und Vorurteilen, die sich in Gesprächen mit Stakeholdern der Schweinefütterung herauskristallisiert haben. Zustimmung oder Ablehnung wurden im Rahmen einer 5-stufigen Skala (1=stimme voll zu bis 5=stimme gar nicht zu) vom Likert-Typ ermittelt. Zusätzlich konnten die Probanden die Antwortmöglichkeit „kann ich nicht beurteilen" ankreuzen, um Meinungen auszuschließen, die ohnehin geringes Gewicht bei der Entscheidungsfindung haben. Die Anordnung der Statements wurde in randomisierter Reihenfolge durchgeführt. Die Statements werden mittels T-test zwischen Roggenanwendern und Roggenvermeidern verglichen. Eine Einbindung in das ökonometrische Modell war nicht möglich, da die Option „kann ich nicht beurteilen" zwar die Datenqualität verbessert, aber die fehlenden Einstellungen eine ökonometrische Untersuchung erschweren.

5. Ergebnisse

5.1 Stichprobenbeschreibung

Die Stichprobe besteht aus 87 deutschen Schweinehaltern. Die Datenqualität wurde geprüft, wobei unvollständige und widersprüchliche Datensätze [6] ausgeschlossen wurden. Schwerpunktmäßig kommen die Betriebe aus Nordwestdeutschland. Die Betriebe teilen sich auf in 81 Schweinemäster, 31 Ferkelaufzüchter und 24 Sauenhalter. Dabei gibt es Überschneidungen, da viele Sauenhalter auch Ferkel und Mastschweine halten. In Niedersachsen, wo die überwiegende Zahl der Halter ansässig sind, liegt die Tierzahl pro Betrieb über dem Bundesdurchschnitt (STATISTISCHES BUNDESAMT, 2016). Die Betriebe bewirtschaften im Schnitt 145 ha Ackerland. Insgesamt haben 12 Teilnehmer kein Ackerland zur Verfügung. Somit kann festgestellt werden, dass mindestens 13,8 % der Stichprobe einen reinen gewerblichen Tierhaltungsbetrieb führen (KLAPP et al., 2011). 59 % aller Betriebe füttern neben anderen Komponenten auch Getreide aus eigenem Anbau (Tabelle 2). Bezüglich des Roggeneinsatzes kann bereits vermerkt werden, dass die Betriebe in der Stichprobe 28 % der Roggeneinsatzkapazität ausschöpfen, wobei ein Betrieb mit 111 % auch über die DLG-Empfehlung hinaus Roggen verwendet (Tabelle 2).

[6] Ein Qualitätscheck hat zum Ausschluss eines Jungsauenbetriebes geführt, da die Tierzahl nicht mit den anderen Angaben des Teilnehmers übereinstimmen kann.

Tabelle 2 Stichprobeneigenschaften

Variable	Einheit	N	Ø	SD	Min	max
Betriebsinterne und Soziale Faktoren						
Roggeneinsatz (binär)	1= Roggeneinsatz > 0 %	87	0,68	0,47	0	1
Roggeneinsatzmenge	% an Fütterungsration relativ zu DLG-Empfehlung	87	0,28	0,31	0	1.11
Bewertung soziales Umfeld	Likert Typ 1-5, 1=sehr positive Bewertung des Umfeldes	87	3,60	0,71	2	5
Roggenanbaugebiet	Roggenanbauintensität 6 stufige Skala	87	2,6	1,51	1	6
Roggenanteil eigener Anbau	% Roggenanteil an betriebsinterner Fruchtfolge	87	11,89	13,44	0	70
Betriebsschwerpunkt Schweinehaltung	1= Schwerpunkt Schweinehaltung	87	0,51	0,50	0	1
Selbstmischer	1= Selbstmischer	87	0,59	0,50	0	1
Tierzahl	Anzahl Tiere im Betrieb	87	2857	2597	20	15450
Schweinemäster	1= Schweinemäster	87	0,93	0,25	0	1
Ferkelaufzüchter	1= Ferkelaufzüchter	87	0,36	0,48	0	1
Sauenhalter	1= Sauenhalter	87	0,28	0,45	0	1
Konventionell	1= konventioneller Betrieb	87	0,97	0,18	0	1
Ackerland	in ha	87	144,52	124,31	0	680
Soziodemografische Faktoren						
Alter	in Jahren	86	35,10	12,76	16	62
Geschlecht	1= männlich	87	0,93	0,25	0	1
Meister-Betriebswirt	1= landwirtschaftlicher Meister oder staatlich geprüfter Betriebswirt	87	0,36	0,48	0	1
Studium	1= Studium der Agrarwissenschaften	87	0,40	0,49	0	1
Betriebsleiter	1= Betriebsleiter	87	0,45	0,50	0	1
Hofnachfolger	1= Hofnachfolger	87	0,3	0,46	0	1

N=Observationen, Ø=Mittelwert, SD=Standardabweichung, Min und Max=Bandbreite der Observationen

5.2 Persönliche Einstellungen zum Roggen und dem Roggeneinsatz

Um einen Eindruck über Vorbehalte und die persönlichen Einstellungen der Schweinehalter zum Einsatz von Roggen in der Schweinefütterung zu bekommen, wurden die Mittelwerte einzelner Variablen mit einem T-Test auf Signifikanz geprüft (Tabelle 3). Dabei wurden die Schweinehalter, die Roggen als Futtermittel einsetzten, mit denen verglichen, die keinen Roggen in der Schweinefütterung einsetzen.

Die Ergebnisse in Tabelle 3 zeigen auf, dass es zwischen den beiden Gruppen signifikante und zum Teil hoch signifikante (Signifikanzniveau 99%) Unterschiede gibt. Dabei schätzen die Roggenanwender stets die Eigenschaften des Roggens positiver ein. Beispielsweise ist die Zustimmung zu „Roggen schmeckt den Schweinen nicht“ größer bei den 23 Roggenvermeidern als den 54 Anwendern. Der T-test bescheinigt einen hoch signifikanten Unterschied. Die spezifischen Unterschiede werden in der abschließenden Diskussion analysiert.

Tabelle 3 Mittelwertvergleiche Roggenanwender – Roggenvermeider

Variable	Kein Roggeneinsatz			Roggeneinsatz			T-test H0: Diff.=0	
	N	Ø	SD	N	Ø	SD	Pr (|T| >|t|)	Sign
Roggen liefert von allen Getreidearten die preisgünstigste Energie	23	2,57	0,84	57	2,11	0,98	0,051	
Roggen verursacht Durchfall	20	3,95	0,89	55	4,18	0,77	0,273	
Der hohe Anteil von Nicht-Stärke-Polysacchariden im Roggen führt zu einer geringeren Verdaulichkeit von Nährstoffen (Käfigeffekt)	21	2,81	0,93	43	2,86	0,80	0,822	
Kostengünstige Futterenzyme, spalten Nicht-Stärke-Polysaccharide auf, dadurch stehen mehr Nährstoffe des Roggens zur Verfügung	17	2,41	1,00	41	2,22	0,79	0,440	
Roggen verursacht steife Knochen	12	4,00	0,95	38	4,11	0,80	0,706	
Der Mutterkornanteil moderner Sorten ist unproblematisch	24	3,13	0,99	52	2,87	1,12	0,334	
In modernen Schweinezuchtlinien ist auch bei hohen Roggenanteilen die Futteraufnahme gut	18	2,78	1,22	49	2,24	0,80	0,042	*
Aufgrund des geringen Eiweißgehalts eignet sich Roggen gut um die N-Ausscheidungen der Schweine zu reduzieren (N-reduzierte Fütterung)	22	2,95	1,05	47	2,79	1,06	0,542	
Roggen schmeckt den Schweinen nicht	23	2,78	1,13	54	3,67	0,91	0,001	**
Hohe Roggenanteile verursachen Schaumbildung in der Flüssigfütterung	15	2,47	1,36	36	3,67	1,26	0,004	**
Roggen ist weniger anfällig für Fusarium und dadurch weniger Mykotoxin-belastet als Weizen	22	3,18	1,26	51	2,63	1,00	0,049	*
Roggen sorgt für eine gute Speckqualität	14	3,29	0,91	28	3,00	0,90	0,341	
Bitterstoffe im Roggen verhindern eine hohe Futteraufnahme	21	3,00	1,22	56	3,45	1,14	0,139	
Durch den Mutterkornanteil ist die Mykotoxinbelastung höher als bei anderen Getreidearten	26	2,00	0,94	54	2,83	1,27	0,004	**
Roggen hat eine geringe Aminosäureverdaulichkeit	19	2,68	0,89	40	2,83	0,93	0,584	
Bitterstoffe spielen in modernen Roggensorten keine Rolle mehr	19	3,16	1,12	47	2,94	1,17	0,483	
Bei Roggen als Getreidekomponente muss mehr Sojaschrot gefüttert werden	19	3,00	1,15	54	2,76	1,21	0,454	
Roggenanbau ist nur auf sehr leichten Böden sinnvoll.	21	2,00	1,14	53	2,62	1,23	0,049	*
Roggen verträgt keine Gülledüngung, da er schnell ins Lager geht.	20	2,90	1,29	53	4,00	1,07	0,000	**
Roggen verursacht die niedrigsten Produktionskosten pro t im Vergleich zu anderen Getreidearten.	22	3,05	1,68	54	2,06	1,07	0,003	**
Roggen erzielt auch auf mittleren- guten Böden konkurrenzfähige Erträge.	22	3,41	1,30	54	2,50	1,26	0,006	**
Roggen verursacht hohe Erntekosten durch hohen Strohanfall und Lagerneigung.	17	2,76	1,20	53	3,45	0,95	0,018	*
Roggen lockert die Fruchtfolge auf.	21	2,48	1,44	54	2,46	0,99	0,964	

Tabelle 3 fortgesetzt

Hybridroggen liefert stabile Erträge auch unter schwierigen Bedingungen.	22	2,91	1,72	54	2,17	1,08	0,026	*
Roggen hat die geringsten Ansprüche an den Wasserbedarf, die N-Düngung und den Pflanzenschutz, im Vergleich zu anderen Getreidearten.	22	2,27	1,64	54	1,85	1,05	0,186	
Roggen erzielt mindestens vergleichbare Erträge mit Triticale und Weizen.	22	3,82	1,65	54	2,61	1,20	0,001	**

Hinweis: N variiert aufgrund der Option „kann ich nicht beurteilen". Die Variablen wurden auf einer Skala von 1= Stimme voll zu bis 5=stimme gar nicht zu; Die P-Werte (Pr(|T| > |t|) zur T-test-Statistik sind angegeben und signifikante Werte markiert: *=5%-Level und **=1%-Level

5.3 Zweistufiges Modell zum Roggeneinsatz

Zur Überprüfung des Zusammenhangs betrieblicher und externer Faktoren beim Roggeneinsatz kam ein zweistufiges Modell zur Anwendung. Dabei wurde zuerst versucht den besten Schätzer für das Model zu finden. Aus der Datenstruktur fällt auf, dass der Anteil an Schweinehaltern, die grundsätzlich keinen Roggen füttern, 32% beträgt. Durch die vielen Nullwerte ist der Roggeneinsatz nicht normalverteilt, weswegen ein einfaches OLS-Modell nicht angebracht erscheint. Ein häufiger Ansatz, der die gegebene Verteilung berücksichtigt, bezieht sich auf das Tobit-Modell. Tobit würde jedoch den Modell-Einfluss auf den Roggeneinsatz und die Menge des Einsatzes miteinander vermischen. Der Einsatz von Verbrauchsgütern kann aber auch mit zweistufigen Modellen analysiert werden. RICKER-GILBERT et al. (2011) trennen den Prozess, welcher den binären Einsatz von Dünger und jenen, der die Düngereinsatzmenge beschreibt. Das verwendete Double Hurdle (DoHu)-model von CRAGG (1971) berücksichtigt diese Möglichkeit und erlaubt es uns die binäre Entscheidung nach Roggeneinsatz in der Fütterung (ja oder nein) und die Menge des Roggeneinsatz durch zwei unterschiedliche Prozesse zu analysieren. Der Likelihood-Ratio Test nach GREENE (2003) stützt unsere Annahme von zwei Prozessen und bevorzugt das DoHu über das einstufige Tobit, welches im DoHu verschachtelt ist. Der Vergleich nach GREENE (2003) zeigt, dass die LR-Statistik (=20,36) größer ist als der kritische Wert der inversen Chi²-Verteilung (14.07 bei k=7, p=0.05), weshalb das Dohu-Model dem eingeschränkten Tobit Modell vorzuziehen ist. Der Modellaufbau wurde auch hinsichtlich Multikollinearität (max. r=0,35) und anderen Modelleigenschaften geprüft[7]. Die Modellgüte ist durch den P-Wert für die Wald-Chi²-Statistik als adäquat zu bezeichnen (Prob > chi2 = 0,0001) (CRAGG, 1971). Ebenfalls ist der Log-Likelihood in Anbetracht der Stichprobengröße zufriedenstellend (Log likelihood = -20,9) (Tabelle 4). Die Berechnung des DoHu-Modells und der marginalen Effekte erfolgte unter Anleitung von BURKE (2009) innerhalb des Statistikprogrammes STATA. Das Regressionsmodell erklärt sowohl die binäre Entscheidung zum Roggeneinsatz als auch die Roggeneinsatzmenge in der Fütterung. Dadurch können externe und betriebsinterne Faktoren jeweils für einen der beiden Entscheidungsprozesse bestätigt oder abgelehnt werden (Tabelle 4). Signifikante marginale Effekte sind gekennzeichnet (*).

[7] Wir gehen nicht von Scheinkorrelationen oder Suppressor-Beziehungen unserer Modellvariablen mit nicht erhobenen Variablen aus. Eine Analyse des Modells nach Heckman führt nicht zu einer signifikanten mills-ratio, was unsere Annahme stützt (WOOLDRIDGE (2002)).

Tabelle 4 Betriebsinterne und externe Roggeneinsatzfaktoren

	Faktoren	Roggeneinsatz (binär)			Roggeneinsatz (fortlaufend)		
		ME	SF	P>z	ME	SF	P>z
Extern	Bewertung des Umfeldes (1=positiv, 5=negativ)	-0,197**	0,132	0,005	-0,134	0,092	0,113
Extern	Roggenanbaugebiet (1=kein Anbau, 6=intensiver Anbau)	0,131	0,088	0,105	-0,087	0,060	0,804
Betriebsintern	Roggenanteil an Fruchtfolgen (in %)	0,013**	0,009	0,003	0,008*	0,005	0,022
Betriebsintern	Schweineschwerpunkt (=1)	0,203*	0,137	0,031	-0,009	0,006	0,873
Betriebsintern	Selbstmischer (=1)	-0,135	0,091	0,050	0,275**	0,189	0,003
Betriebsintern	Tierzahl (Anzahl)	0,000	0,000	0,177	0,000	0,000	0,209
N			87				
Prob > chi2 =			0,0001				
Log likelihood =			-21.143				

ME=marginale Effekte, SF=Standardfehler, P>z=P-Wert, KI=Konfidenzintervall, Signifikanzniveaus: *=5%-Level und **=1%-Level

5.3.1 Externe Faktoren

Der Einfluss des Umfeldes kann als Einflussfaktor bestätigt werden. Es wird aufgezeigt, dass das soziale Umfeld hoch signifikant für die binäre Barriere zum Roggeneinsatz ist (p=0,005), nicht aber die Höhe des Roggeneinsatzes beeinflusst (p=0,113). Beim Roggenanbaugebiet wurde ein insignifikanter aber positiver Einfluss auf die binäre Bereitschaft zum Roggeneinsatz festgestellt (p=0,105), während hingegen der geschätzte Modelleinfluss auf die Roggeneinsatzmenge annähernd Null ist (p=0,804).

5.3.2 Betriebsinterne Faktoren

Schweinehalter, die selbst die Futterrationen mischen und daher unabhängiger von Futtermittellieferanten agieren, zeigen einen signifikanten Zusammenhang mit der Roggeneinsatzmenge (p=0,003). Dem gegenüber steht die Entscheidung grundsätzlich Roggen zu verwenden, wo die Bezieher von Fertigmischung häufiger Roggen einsetzen (p=0,050). Der Betriebsschwerpunkt, in diesem Fall die Schweinehaltung, erweist sich als signifikanter Faktor bei der binären Entscheidung zum Roggeneinsatz (p=0,031). Der Schweineschwerpunkt bedingt jedoch nicht eine höhere Roggeneinsatzmenge in der Futtermischung (p=0,873). Der Roggenanbau auf dem eigenen Betrieb spielt bei der Entscheidung über den Einsatz als Futtergetreide sowie der Menge in der Ration eine Rolle. Dieser Faktor weist eine deutlichere Erklärungskraft für den Roggeneinsatz auf. Die Tierzahl auf dem Betrieb hat keinen signifikanten Einfluss. Eine Berechnungen des Modells unter Ausschluss der größten Betriebe (Tierzahl>10000) bestätigt das Ergebnis.

6. Diskussion

Bei der Analyse der betrieblichen Roggeneinsatzmenge zeigt sich, dass der überwiegende Teil der Schweinehalter noch Kapazität hat, um den Roggeneinsatz in der Schweinefütterung zu steigern. Außerdem erscheinen der binäre Entschluss Roggen zu füttern und die Entscheidung über die

Roggeneinsatzmenge als zwei unabhängige Entscheidungsprozesse, die durch unterschiedliche Faktoren geprägt sind.

6.1 Persönliche Faktoren

Aus der Auswertung zur persönlichen Einstellung der Schweinehalter geht hervor, dass zwischen Personen, die Roggen als Futtergetreide einsetzten, und Personen, welche keinen Roggen in der Schweinefütterung verwenden, signifikante Unterschiede existieren. Zunächst nehmen sowohl Anwender als auch die Vermeider den Roggen überwiegend als preisgünstigen Energielieferanten wahr (Tabelle 3). Die Wahrnehmungsunterschiede beginnen dann aber bereits beim Anbau. Roggenvermeider empfinden einige Anbaueigenschaften relativ kritisch, wobei diese Eigenschaften in der Fütterung wohl keine unmittelbare Bedeutung haben. Es kann daher vermutet werden, dass eine negativere Wahrnehmung beim Anbau, auch das Image des Roggens als Futtermittel prägt. Bei den klassischen Anbauparametern unterscheidet sich die Wahrnehmung zu Erträgen, Produktionskosten und Lagergefahr bei Gülleeinsatz. Die kritische Anbau-Einschätzung spielt bei innerbetrieblichen Wertschöpfungsketten, also dem eigenem Anbau von Futtergetreide für die Tierhaltung, eine besondere Rolle. Im Fütterungsprozess heben sich drei Aspekte hervor. Die Mykotoxinbelastung in Verbindung mit dem Mutterkornanteil wird möglicherweise von Roggenvermeidern überschätzt, da hier erst in den vergangenen Jahren Züchtungsfortschritte erhebliche Verbesserungen mit sich gebracht haben (MEYER et al., 2003; WEBER et al., 2004; WEBER, 2012; MEYER, 2013). Im Vergleich zu anderen Getreiden ist die Mutterkornanfälligkeit *(Claviceps Popurea*) beim Roggen aber immer noch am stärksten ausgeprägt. Im Gegensatz dazu schneidet der Roggen bei der Fusarium-Anfälligkeit besser ab als das Substitut Weizen (MEYER, 2013). Sowohl die Fortschritte beim Mutterkorn als auch die Vorteile bei Fusarium sollten stärker kommuniziert werden, um die Sorge bzgl. der Pilzbefälle zu mildern. Das Problem der Schaumbildung in Flüssigfütterungsanlagen kann durch Zugabe von Pflanzenölen vermieden werden (GAGERN, 2007), erfordert aber einen zusätzlichen Management-Schritt[8]. Die Sorge der Schweinehalter, dass Roggen den Tieren nicht schmeckt, kann ebenfalls wissenschaftlich nicht bestätigt werden (MEYER et al., 2006; MEYER, 2013). Verschiedene weitere Einstellungen zeigen (Tabelle 3), dass die Wahrnehmung des Roggens zwischen Anwendern und Nichtanwendern auch identisch sein kann. Fruchtfolgeeigenschaften, Wasserbedarf, Pflanzenschutz und Pflanzendüngung werden ähnlich wahrgenommen. Bei der Fütterung zeigen sich keine Unterschiede bezüglich zusätzlichem Einsatz von Sojaschrot, Bitterstoffen, Aminosäureverdaulichkeit, Speckqualität, Futteraufnahme, Stickstoffausscheidung, Verursachung von steifen Knochen, Mutterkornanteil moderner Sorten, Nicht-Stärke-Polysacharide, Verursachung von Durchfall und preisgünstiger Energie. Dies zeigt einige Felder auf, die wohl mittlerweile eine untergeordnete Rolle für die Roggenvermeidung spielen.

[8] Bivariate Korrelation betrieblicher Flüssigfütterung und Roggenvermeidung r=0,19

6.2 Externe und betriebsinterne Faktoren

Einen Einfluss auf den Einsatz von Roggen, wie auch aus der Literatur hervorgeht (SOLANO et al., 2003), hat das soziale Umfeld des Schweinehalters[9]. FUNK (1982) hat herausgefunden, dass der Händler für Landwirte bei Beschaffungsmaterialen eine entscheidende Informationsquelle darstellt. Die Roggenbewertung und das Angebot von Futtermittelhändlern können also einen Beitrag zur Erklärung zum Roggeneinsatz liefern. Händler und Berater tragen möglicherweise zum geringen Roggeneinsatz bei. In dem Regressionsmodell wurde auch das Roggenanbaugebiet als mögliche Einflussvariable berücksichtigt. Hier zeigte sich kein signifikanter Zusammenhang. Die Annahme, dass der Roggen in den Überschussregionen etwas günstiger ist als in den Zuschussregionen (ZINKE, 2015), oder dass Landwirte in roggenstarken Regionen von je her einen stärkeren Bezug zur Roggenfütterung haben (MEYER et al., 2006), beschreibt den Roggeneinsatz nur unzureichend. Das Roggenanbaugebiet spielt eine untergeordnete Rolle, während der Roggenanbau auf dem eigenen Betrieb, nicht überraschend, Erklärungskraft für den Roggeneinsatz bietet. Bei der Roggenmenge in der Futtermischung unterscheiden sich die Betriebe, die ihr Futter selber mischen, und jene, die Fertigfutter einkaufen und entsprechend weniger Roggen verwenden. Ein Grund dafür könnten die standardisierten Rezepturen der Mischfutterwerke sein, die womöglich nur einen geringen Roggenanteil einplanen. Dies würde die Tendenz zu einer häufigeren Entscheidung für den Roggen einerseits und die geringeren Einsatzmengen der Bezieher von Fertigmischungen andererseits erklären. Es bleibt offen, ob Mischfutterwerke lediglich auf Bedenken der Abnehmer reagieren oder eigene innerbetriebliche Faktoren die Roggeneinsatzmenge in den Mischfutterwerken kennzeichnen. Betriebe mit einem Betriebsschwerpunkt in der Schweinehaltung weisen einen signifikanten positiven Einfluss auf die grundsätzliche Entscheidung bzgl. des Einsatzes von Futterroggen auf. Der Schwerpunkt führt daher zu einer stärkeren Berücksichtigung von Roggen. In diesen Betrieben ist die Beschaffung von Futtermittel ein primärer Bestandteil des Betriebsablaufs. Auch hier bestehen jedoch noch Vorbehalte, die zu vorsichtigen Einsatzmengen führen. Insgesamt setzen Betriebe mit und ohne Schweineschwerpunkt vergleichbare Mengen ein. Ein Zusammenhang mit den betrieblichen Tierzahlen kann an dieser Stelle nicht bestätigt werden.

7. Fazit

Die vorliegende Studie leistet einen Beitrag zum Verständnis der Entscheidungsfindung von Landwirten. Es konnten externe und betriebsinterne Faktoren identifiziert werden, die recht unterschiedlich mit der Entscheidung über den Roggeneinsatz und der Entscheidung über die Roggeneinsatzmenge in Verbindung gebracht werden können. Eine getrennte Analyse dieser beiden Entscheidungsprozesse könnte auch für andere Futtermittel-Fragestellung von Interesse sein. Die maximal empfohlene Roggeneinsatzkapazität wird von nahezu keinem Schweinehalter ausgeschöpft. Schweinehalter, die keinen Roggen als Futtergetreide einsetzen, bewerten Roggen bezüglich der Anbauerträge, der Lagergefahr bei Gülleeinsatz und der Mutterkornbelastung schlechter, als jene Schweinehalter, die Roggen in der Futterration haben. Negative Einstellungen zum Pilzbefall oder zur

[9] Bei einem Vergleich mit der zusätzlich erhobenen Frage zur eigenen Gesamteinschätzung des Roggens in der Fütterung fällt auf, dass die Landwirte selbst die Eignung des Roggens etwas besser einschätzen als ihr Beratungsumfeld.

Lagergefahr können teilweise durch aktuelle Forschung entkräftet werden, was stärker kommuniziert werden könnte. Eine negativere Wahrnehmung bei der Fütterung findet sich häufig auch in der Wahrnehmung des Roggens im Getreideanbau wieder. Beim Einsatz von Roggen in der Fütterung haben die Betriebe, die ihr Schweinefutter selber mischen, einen höheren Anteil an Roggen in der Ration als Betriebe, die Fertigfutter zukaufen. Aufgrund der Verabschiedung der Düngeverordnung (BUNDESMINISTERIUM FÜR ERNÄHRUNG UND LANDWIRTSCHAFT, 2015) und dem daraus resultierenden möglichen Interesse der Ackerbaubetriebe die Roggenproduktion auszuweiten, ist Mischfutterwerken zu empfehlen sich stärker mit dem Roggenanteil in den Rationen zu beschäftigen.

Als Restriktionen der Studie lassen sich die geringe Stichprobengröße sowie die regionale Konzentration auf Nordwestdeutschland nennen, die die Repräsentativität der Studie reduzieren. Eine umfangreichere Stichprobe erlaubt auch eine getrennte Analyse von Sauen-, Ferkel- und Mastschweinehaltern, da die Ergebnisse dieser Studie andeuten, dass zumindest der relative Roggeneinsatz im Verhältnis zur DLG-Empfehlung erhebliche Unterschiede aufweist. Außerdem bietet die Studie Querschnittsdaten. Es können keine kausalen Beziehungen belegt werden, sondern lediglich Assoziationen zwischen Faktoren und dem Roggeneinsatz empirisch geprüft werden. In folgenden Studien könnte beispielsweise die Rolle von Gewohnheitsentscheidungen oder die Risikowahrnehmung von landwirtschaftlichen Entscheidungsträgern beleuchtet werden. Auch eine Analyse der durch die Mischfutterwerke vertriebenen Futterrationen kann die Faktoren identifizieren, die die Roggeneinsatzmenge limitieren. Schon jetzt bietet die Studie weitreichende Anhaltspunkte zur Identifikation von Landwirten, bei denen ein hohes nicht ausgeschöpftes Potenzial bezüglich des Einsatzes von Roggen besteht.

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Excursus 2: GMO sets the stage for media coverage on intellectual property rights and market concentration

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Abstract:

The genetically modified crop (GM or GMO) issue has been the first seed sector issue to spin through mass media channels, shaping the opinions of the public. GM is not a lonely seed sector issue in the media. Its presence in the media affects the salience of related issues. A quantitative analysis of 75 German newspapers, with substantial and diverse audiences, reveals that intellectual property rights (IPR) and market concentration (MC) are often framed by GM. The findings indicate that the debate on GM, with all its publicity, has not only directly damaged the seed industry's reputation, but prepares the public for related issues that help antagonists to strengthen a negative image in the media cycle. We discuss implications for the seed sector.

Keywords: biotechnology, genetic engineering, market power, media agenda setting, patents

1. Introduction

Genetically modified crops (GM[10]) are an issue that most people in the European Union (EU) are aware of (82 percent in EU-27) (Gaskell et al., 2010). Among agricultural topics the issue has been particularly controversial with the European public. The industry operates within their legal framework, but society's expectations can exceed the legislation (Gunningham, Kagan, & Thornton, 2004). A public dissatisfaction affects the sectors ability to do business. The seed industry faces the GM issue since the EU's public opinion shifted against GM in the 90s. In 1996, 47 percent of Germans were in favor of the technology. In 2005, only 22 percent remained in favor (Gaskell et al., 2010). The social license to operate captures the risks that a company faces if the public is opposed to their business model. Every industry is inevitably connected to the public. Although buyer boycott can be a lesser concern for business to business sectors, the ability to attract qualified labour, the costs of labour, the trust in products and the legislation framework are affected by public opinions (Albersmeier & Spiller, 2010). The seed industry has witnessed intensive NGO-campaigns interfering with their daily routines. Ultimately, regulatory changes and retailers' fear of consumer reactions have widely prevented the use of GM-crops in the EU (Schurman, 2004)**.** The GM debate has damaged the seed industries reputation, e.g. Monsanto's reputation with the US public is continuously among the worst of visible companies (Harris Poll, 2015).

The media plays a major role in shaping public opinions. The media coverage of an issue affects "what we think about" and "what issues we consider important" (McCombs & Shaw, 1972; Yagade & Dozier, 1990). Most topics do not stand alone in the media. GM has been linked to market concentration (MC), intellectual property rights (IPR) and biodiversity losses (Biodiv). Media research assumes that frequently bundled issues in the media achieve more prominence with the public than a rather isolated one (Vu, Guo, & McCombs, 2014). Newsreaders process news with the help of prior information. Connected issues might foster or elevate the existence of a different issue in the media. Often media attention subsides, due to a loss of momentum or issue fatigue (Mahon & Waddock, 1992; van Tulder & van der Zwart, A., 2006). However, GM has interested European media for over 25 years and continues to do so. Such an issue life span and the widespread awareness that goes hand in hand with it can influence related issue's development in the media. The seed sector's working area is unfamiliar to the average consumer, so that media needs a link to involve the reader and achieve more prominence with the public. Introducing an issue via prior issues, that may have appealed to readers emotionally or rationally, raises interest in an article and helps to generate interest in a related issue.

In order to grasp potential media consequences caused by the lasting GM debate and to foresee media hazards for the seed sector, we carry out a print media analysis that identifies GM's overlap with IPR, MC and Biodiv. The analysis of linkages prioritizes which issues need to be settled with stakeholders first in order to improve the reputation. We will explain why all of these issues can be perceived negatively and may damage the seed industry's reputation. We hypothesize: GM is utilized in the media to prepare the reader for the other issues, so that plenty media coverage of related issues is written with references to GM. The theoretical background draws on issue life cycle and media agenda setting theory. We briefly introduce GM's history with the media. The empirical analysis is based on a

[10] Although the term GMO is recognized in the scientific literature, we use GM throughout the article. GMO includes bacteria and other organisms, while we focus on genetically modified crops for food supply purposes.

diverse set of 75 German newspapers, presenting a comprehensive cluster from the EU. We discuss implications for the sector.

2. Issue linkages in media research

An "issue" comprises a topic of public and media interest that can damage stakeholder's reputation involved. Linkages describe an overlap an issue can have with another. Issue are linked by content, but can also be linked by common stakeholders. Despite scarce research on media linkages, there are considerable pointers how issues are linked to each other. The literature suggests the theoretical concepts of issue life cycles (ILC) and media agenda setting (MAS).

2.1 Issue life cycles on linkages

ILC theorists focus on the public interest towards an issue. They often consider the stakeholders involved (Bigelow, Fahey, & Mahon, 1992; Mahon & Waddock, 1992; van Tulder & van der Zwart, A., 2006). While they are less concerned with the interrelations of issues, they do acknowledge issue competition (Bigelow et al., 1992; Downs, 1972). Macro-issues do not just compete for coverage but consist of multiple related or sub-issues with occasional controversy that increases the cost of change and extend the issue's life cycle, *e.g.* coverage on burglary in pig husbandries can fuel the animal welfare debate. The end of an issue life cycle is dynamic and depends on the satisfaction of stakeholders (Mahon & Waddock, 1992; van Tulder & van der Zwart, A., 2006), such as NGOs, companies and lawmakers. After an issue has been through the attention cycle, it can still reappear in the media (Downs, 1972). The public has prior knowledge on the issue, so that reappearing on the media agenda takes less effort than to appear for the first time. New concerns can be added to the reader's existing information. The existing information can spillover from one issue to a related issue and provide an information base for media coverage. The media utilizes prior information of readers. "Important aspects of it (the issue) may become attached to some other problem that subsequently dominates the center stage" (Downs, 1972). The case describes how one issue can elevate another.

2.2 Media Agenda Setting on linkages

Media agenda setting (MAS) research offers concrete research on media perception and linkages. Our interest lies with linkages or what we associate an issue with. An issue is not isolated, but information is added to existing knowledge. This creates a "picture in our head" (Johnson, 2013). A meta study by Atkinson, Lovett, and Baumgartner (2014) gives an overview of research regarding media effects on public opinion. However, the analysis is limited to what and how rather than the interrelations of an issue. Here, Vu et al. (2014) add a concept by including quantitative linkages in the analysis of media effects on the public. They apply a "Network Agenda Setting Model" to compare links in media coverage with links in public understanding. They not only confirm a strong relationship among associated issues across time in the public and media agenda, but they also find the more connected an issue is in the media, the more recognition it receives from the public. "The news media bundled issue objects and made them salient in the public's mind" (Vu et al., 2014). Conclusively, issue's linkages provide media characteristics that help related issues to make the news and extend the scope and salience of the original one.

2.3 Seed industry's issue linkages

GM has been a salient issue, especially in Europe (Gaskell et al., 2010). The intensive media coverage has opinionated a large share of consumers. At least partially the salience is the achievement of specific pressure groups (Lockie, 2006). In the beginning of the 90s, the German Green Party and a variety of NGOs, like Greenpeace Switzerland or Grain Barcelona, raised concerns related to GM-technologies. Their concerns targeted a rather broad scope, including intellectual property rights (IPR) on life forms (Purdue, 2000), sustainable agriculture, labelling requirements, health and environmental risks. While the mentioned issues remained unresolved, more NGOs followed, such as Greenpeace international or the British Soil Association. These NGO's have fueled an anti-GM Movement (Schurman, 2004). Additional events and political decisions that influenced media coverage are diverse, e.g. the anti-GM statements made by England's Prince Charles (Nisbet & Huge, 2006) or the EU's revision of the directive 90/220/EEC on GM crop regulations (Schurman, 2004). Activism has fueled the media coverage, which shifts public opinions and influences politics, which again fuels activism and media attention (Farre, Twyman, Zhu, Capell, & Christou, 2011). These processes in the Biotech-sector build a cycle of negative reinforcement.

Activist's campaigns and media coverage provide a starting point to identify issues related to GM. Schurman (2004) outlines a GM-critique: "(the biotech-industry) seeks to patent the 'building blocks of life' as a means of gaining control over the world food supply". Purdue (2000) associates the emergence of the GM movement to the patenting of life forms via biotechnology and the global crisis of natural and agricultural biodiversity. The scholars link GM to concerns on (1) Intellectual property rights of seeds (IPR), on (2) market concentration (MC) and on (3) the reduction of agricultural and associated biodiversity (Biodiv). Between 1984 and 2010, 84 percent of seed patent applications issued with the World Intellectual Property Organization (WIPO) involved GM breeding techniques (Then und Tippe, 2011)[11]. The comparably high Research and Development (R&D) costs of GM varieties play a role in the choice of IPR protection mechanism. Higher R&D costs can lead to a substitution of the classic seed variety rights by stronger protection with patents. In contrast to seed variety rights, a patent prohibits competitors and public institutions to continue research with marketed genetic material (Bette und Stephan 2009). Further, the higher R&D cost of GM-plants can exclude small and medium enterprises with limited resources (Bette und Stephan 2009). Such interdependencies hypothesize a structural GM-IPR-relationship. The link between GM and biodiversity losses is still investigated with conflicting findings. Drawing on empirical data Qaim, Yarkin, and Zilberman (2005) reject a negative influence of GM on crop genetic diversity.

IPR, MC and Biodiv possess their own issue structure and do also relate to each other. Small and medium enterprises with limited resources are unable to conduct research and enforce their patent rights. A patent is a costly matter. Juristic cases on patent infringements (Singh, Prasad, & Reddy, 2013) or patent application procedures (Bette und Stephan 2009) exclude smaller enterprises from participating in patent protection. Both aspects contribute to market concentration. Pressure groups like "no patent on seeds" or NGOs that utilize the term "Agropoly" intend to push the MC-IPR link onto the media agenda. Concerns that monopolization has spread too far have existed for some time (Brennan, Pray, Naseem, & Oehmke, 2005; Howard, 2009; Singh et al., 2013). The controversial World Bank study (IAASTD, 2009) connects market concentration with the prevention of new firm market entries and a concentration of research on fewer seed lines. The remaining firms are likely to eliminate

[11] The primary data from WIPO could not be sourced for confirmation of the claim

less profitable seed lines from newly acquired companies (Howard, 2009), hence reduce agricultural plant diversity. The discussed relations imply a decent probability to find all four issues on the media agenda and therefore in the public's mind in a combined manner.

3. Methodology

3.1 Measurement concept

The main measurement concept in media research is "media salience". Salience stresses the attention devoted to an issue in the media. The concept of salience varies among researchers, so that different measurement approaches are applied. Kiousis (2004) identified and structured salience concepts and measurements. First of all, the most common measure is the sheer volume of articles (Kiousis, 2004). Other approaches include the space dedicated to an issue, the page number in print news, etc. (Kiousis, 2004). In the end, salience remains a relative measure, over time or compared to other issues, as no threshold for salience levels have been defined. Following Vu et al. (2014), we analyze issue linkages with the number of overlaps in articles. We count the co-occurrences of issues in newspaper articles and compare the results to the overall coverage of each individual issue. The reader may additionally interpret volume of articles on the individual issues, as they allow for a relative comparison of salience magnitude.

Further confirmation of overlaps is achieved with headline scans. A strong headline possesses suitable media characteristics: novelty, negativity, controversy and potential widespread impact (Anderson, Brossard, & Scheufele, 2012). The restriction to headlines implies an improved recognition of an issue relative to an issue in the article text. To the best of our knowledge, the headline indicator has not been applied in media research. Issues that connect to prior knowledge of readers are better recognized by the public (Johnson, 2013). Headlines that connect to widely known related issues in the text, can also expect improved recognition. Drawing on a headline search option, we count issues' occurrences in headlines and count headline articles conditional on the appearance of related issues. This allows for a comparison of the frequency an issue taps on a related one, when being pushed in the media cycle.

3.2 Keyword design

The keywords for GM are inspired by Garcia-Yi et al. (2014) efforts to map GM-synonyms. Other issues required extensive time in order to brainstorm and validate keywords. In the beginning we collected common wordings in the media landscape. Capturing many widely-spread expressions was important to avoid a bias in data collection. Keywords that returned one or no article were dropped from the keyword list. Early versions of the keyword searches returned a large set of articles, but included a broad mix of topics unrelated to the seed sector. We narrowed our set by excluding all articles that did not mention a synonym of seed, *e.g.* to exclude articles on genetic modification in medical applications.

Most articles on the seed sector fulfil this criterion[12]. Duplicates, identical articles in different newspapers, are filtered out. The keyword search pattern over the different issues is uniform to ensure

[12] Agriculture-biotech! (in German "Agrarbiotechnologie!") is a term that relates biotech to the seed sector without using a synonym of "seed". The writing approach is not too common in the German media. Valid GM newspaperarticles, which use a synonym of "Agrarbiotech! OR Agrar-biotech!", are fewer than 20, in comparison

an unbiased data collection. The search options of the database allow for a quantitative keyword search in the headline and/or the main text body. Afterwards, two coders scanned for falsely included articles. Thereby, we account for the statistical type I error for false hits, but not for type II error of the false rejection of an article. Concluding, the article volume is most likely still underestimated, which is equally true for each issue. The search terms are provided in the Appendix (Table A1).

3.3 Database

In order to identify the linkages and leadership roles among issues, we compiled a diverse set of print media. We used Lexis' archive of 75 German newspapers[13]. The set represents rural and urban areas, as well as geographical diversity with Eastern, Southern, Northern and Western Regions. Politically, the spectrum is broad from conservative to liberal leaning papers. The sample is less biased than 1 or 2 broadsheet newspapers (Lockie, 2006). The common broadsheet newspaper approach incurs a bias with respect to the audience properties: region, political orientation and more. The full set analysis can easily be reproduced with the help of our keywords. Initially, we did not limit our timeframe of observation, although there are constraints. The issues rarely achieved attention before the 1990s and the first archived newspaper in the sample dates back to January of 1991. The majority of newspapers are only available for less than 10 years[3]. Since most of the archived newspaper timeframes do not cover potential attention peaks of GM in the 90s, as found by (Lockie, 2006; Nisbet & Huge, 2006), our dataset does not allow for a representative analysis of coverage over time. The archived duration of the papers causes a random bias towards later coverage that would be a concern to longitudinal data analysis. However, the coverage potential is identical to the different issues, so we can analyze them relative to each other. We finished data collection by December of 2015.

4. Results

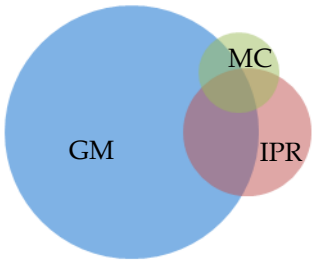
4.1 Seed industry issues co-occur in the media

The print media analysis reassures a relatively high salience of GM. In terms of the volume of articles, the issues are covered in the following order: GM > Biodiv > IPR > MC. The absolute co-occurrences are displayed in a cross-classified table (Table 1). To understand the relevance of co-occurrences for each issue, we also calculated the co-occurrences relative to the overall coverage (Table 1). The percentage of co-occurrences determines the distance between issues. The data shows that 45 percent of IPR articles and 42 percent of MC relate to GM. Biodiv presents greater distance with seventeen percent of articles relating to GM. All issues overlap most with GM, while the extensive coverage of GM is linked comparably less to other issues (four to twelve percent, Table 1). The graph visualizes the coverage volume and the degree of overlap among IPR, MC and GM. In the graph the size of a coverage circle is calculated with respect to article volume relative to other issues. GM, with 3518 articles, represents the largest circle followed by IPR. The results reveal that many articles on seed sector issues are bundled in the media. GM seems to have a leading role, so that IPR and MC are likely to occur bundled with GM.

to a overall coverage of over 3000 articles on the GM issue. We decided to keep a uniform keyword structure between issues.

[13] Full sample of newspapers selected, as defined by Nexus (06/2016). We provide details on archived time, sold copies of newspapers if they sell a high number of copies (Appendix Table A2)

Table 1 Issue overlap by newspaper article's co-occurrences



	GM	IPR	MC	Biodiv
GM	3518	405	148	267
IPR	405	894	146	154
MC	148	146	351	62
Biodiv	267	154	62	1526
Percentage of occurrences				
% GM	1	0.45	0.42	0.17
% IPR	0.12	1	0.42	0.10
% MC	0.04	0.16	1	0.04
% Biodiv	0.08	0.17	0.18	1

GM=genetically modified, IPR=intellectual property rights, MC=market concentration, Biodiv=Biodiversity,

4.2 Headline articles framed by related issues

Applying a keyword search in headlines resembles the findings on salience with sheer volume of articles: GM > IPR > Biodiv > MC (Table 2). The gap between GM volume and other issues is smaller with headline articles. The headline count provides an idea of issues relative potential to make the headlines. The linkage is analyzed by the percentages of articles referencing a different issue. While the co-occurrences reveal the frequency two issues are bundled in the media, the headline articles offer an additional indication of what should be the primary and what should be the secondary issue. A secondary issue may only be listed to make the primary one more appealing or more controversial to the reader. GM is often utilized as secondary issue. More than 40 percent of IPR and MC articles reference GM (Table 2). In contrast GM does not utilize secondary issues as often. Only thirteen percent of GM articles reference IPR (Table 2). Similar results are found for MC. Biodiversity is covered rather independently of these issues. The results confirm linkages between IPR, MC and GM. GM stands predominantly independent of other issues. Biodiv is less related to any of the issues. A graph visually presents the volume of headline articles relative to the percentage of headline articles that reference a related issue (Table 2). The graph shows how MC and IPR are framed by GM, but rarely the other way round.

Table 2 Issue overlap by headline articles

	GM	IPR	MC	Biodiv
GM	212	70	12	10
IPR	28	159	21	14
MC	7	44	25	4
Biodiv	15	19	6	119
Percentage of occurrences				
% GM	1	0.44	0.48	0.08
% IPR	0.13	1	0.84	0.12
% MC	0.03	0.28	1	0.03
% Biodiv	0.07	0.12	0.24	1

GM=genetically modified, IPR=intellectual property rights, MC=market concentration, Biodiv=Biodiversity,

4.3 Limitations

The quantitative keyword search can underestimate the number of articles on an issue. The keywords choice may not capture all writing styles that link one issue with another. Current data implies already wide overlaps in media coverage, but a qualitative content analysis may yield additional linkages. Random scans of articles imply a predominantly critical coverage, but a qualitative content analysis can answer future research questions on the relation of tone of coverage and issue linkages, *e.g.* negative press on the seed sector might achieve more public recognition, because it is presented in the context of related issues, while positive press is less recognized, because it is presented isolated from other achievements of the industry. We advise to caution against an interpretation beyond the seed sector. While it is plausible that the most salient issues of a sector drive attention to other sector issues, our analysis is limited to the seed industry and German media landscape. There is still little theoretical background to draw generalizable conclusions on media linkages. Lastly, the analysis is restricted to print media. Although print media has been a primary news channel since the GM issue erupted in the 90s, social media and TV may add a new perspective on GM's perception depending on the information channel.

5. Discussion

Genetically modified crops (GM) are surrounded by a persistent and polarized debate among proponents and antagonists (De Cock Buning, Tjard, Brauw, & van Amstel, 2011). Historically, the GM debate peaked already in the 1990s (Lockie, 2006; Nisbet & Huge, 2006), but GM continuous to attract media attention. On the one hand the media is still interested in GM, because it is an unresolved issue in the eyes of many stakeholders. On the other hand the media has utilized GM to interest the reader in other seed sector topics. We confirm linkages between news articles on market concentration and GM and between news articles on intellectual property rights and GM. The articles, that capture GM and IPR or GM and MC, present a large share of the overall articles on MC and IPR. Both issues are promoted by the existence of GM and may occur less frequent, if the GM issue would have been resolved. In contrast the prodiminant share of GM articles does not also cover another seed sector issue. GM can stand alone in the media. Biodiversity issues are hardly linked to GM in the media.

In terms of sheer volume of articles, MC has been the least salient issue in the print media. The broadsheet media has covered it less, so that the public should not be overly familiar with it.

Nevertheless, MC coverage stands out as extensively linked to GM. The coverage on future mergers in the industry is likely to draw upon GM to introduce MC issues, e.g. the Bayer-Monsanto takeover negotiations, which started after data collection was finalized. GM offers familiarity and negative perceptions which help antagonists to set the tone of coverage on takeover deals. More coverage of the seed sector provides more prior information that the media can utilize. Besides GM we find IPR to be a common reference topic for MC's news articles. Altogether, we assume MC is not an issue of public concern yet, but may grow into one based on its media potential to relate to the pending issues of IPR and GM.

IPR concerns evolved parallel to the GM issue. Pressure groups have long been skeptical of patents on lifeforms (Purdue, 2000). In this decade IPRs on seeds are strengthened at a global level (UN General Assembly, 2009), which adds controversy to its media potential. IPR's regulatory changes might be able to generate interest by itself, but the media does not neglect the advantage IPR has to make the news by building on the salient GM issue. IPR articles often reference GM. As most patents on seeds are filed for GM-varieties, we advise the stakeholders to seek combined solutions for GM and IPR. Antagonist might not be willing to settle the GM issue, if GM helps to push IPR on the media agenda, because IPR concerns prevail.

The linked issues enlarge the management challenge to ease the GM issue. Leaving IPR and MC unresolved may backfire in continuous media coverage, which prevents the sector from rebuilding their reputation. If the industry and opposition groups can find a common approach to future breeding processes than it will inevitably reduce the grounds on which the media covers IPR and MC. A regulation or an industrial self-regulation can help to diminish media attention (Mahon & Waddock, 1992; van Tulder & van der Zwart, A., 2006), but regulations are a dynamic matter. As long as the majority of proponents and antagonists are unsatisfied with the opposition's approach, they will push for public attention to protect or change current regulations. From a reputational point of view we expect a competitive advantage for companies that go ahead and offer positions on issues that are more accepted among antagonists. A convincing approach to issue management and being a thought leader in addressing one issue can improve the reputation, not only with respect to the issue itself, but also improve the public perception of how a company manages a complex of issues (Zyglidopoulos, 2003).

In general, the seed industry should be careful to assume they can do business regardless of the public opinion. Public's expectations need more consideration. A continuously damaged reputation increases the costs of attracting qualified labor, impede regulatory changes and reduces the trust in food products (Albersmeier & Spiller, 2010). Consumer trust in agricultural products is essential to keep final buyers satisfied. The damaged seed sector reputation may even contribute to consumers' skepticism of other topics in the agricultural sector.

We suggest seed marketing and communication should not only target farmers, as we frequently observe in Europe. Building public sympathy requires a basic understanding for why new varieties are bred. Consumers need to comprehend why improved varieties are still required. A consistent consumer education on varieties, that serve tangible public needs, i.e. target health or sustainability concerns rather than glyphosate resistance or yield, can help to regain consumer acceptance. Considering the linkages, the communication efforts cannot neglect intellectual property rights and mergers. Such topics might be even more challenging to defend.

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Appendix A

Table A1 Keyword search terms for issues related to the seed industry

IPR	GM	MC	BIODIVERSITY
(Eigentumsrecht OR Verfügungsrecht OR Urheberrecht! OR Patent OR Patentierung OR patentieren OR patentiert OR patentgeschützt OR patentierbar! OR geistige? Eigentum)	(Gen! Modifi! OR Gen! Manipul! OR Gen! Veränder! OR gen! Optimier! OR Biotech!)	(Monopol! OR Marktkonzentration OR Marktm!cht! OR Marktkontrolle OR Marktf!hrung! OR Marktf!hrerschaft! OR Marktdominanz)	(Sortenvielfalt OR Biodiversität OR biologische Vielfalt OR genetische Vielfalt OR Artenvielfalt OR Pflanzenvielfalt OR Agrobiodiversität OR Nutzpflanzenvielfalt OR Kulturpflanzenvielfalt OR Vielfalt- Kulturpflanzen OR Vielfalt- Nutzpflanzen)
AND (Saatgut! OR Pflanzgut! OR Pflanzensorte OR Kulturpflanze OR Nutzpflanze)			

'!'=undefined number of letters attached to the term, '?' =undefined letter

Table A2 Prominent newspapers in the database

Newspaper	Frequency	Copies sold 01/2015	first issue archived
TAZ	Mo-Sa	63.497	01/1994
Tagesanzeiger	Mo-Fr	188602*	08/2007
Frankfurter Rundschau	Mo-Sa	87.136	01/2000
Die Welt	Mo-Fr	225.583	03/1999
Stuttgarter Nachrichten	Mo-Sa	196.745	07/2004
Stuttgarter Zeitung	Mo-Sa		02/2002
Berliner Zeitung	Mo-Sa	127.756	01/2000
Rheinische Post Düsseldorf	Mo-Sa	330.460	01/2006
General Anzeiger (Bonn)	Mo-Sa	78.683	02/2000
Hamburger Abendblatt	Mo-Sa	203.896	01/2000
Aachener Nachrichten	Mo-Sa	113.495	03/2009
Aachener Zeitung	Mo-Sa		03/2009

Source: a. sold copies: (IVW), b. first issue archieved: Nexus, *copies sold based on 2012

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Conclusions

The thesis' goal is to address the marketing of ideas that can contribute to a sustainable food supply, particularly the adoption of legumes. The articles are a selection of ideas that can enable progress. Pursuing related topics or building on variations of these studies may illuminate different pathways. The thesis' contribution to the scientific literature lies not with inventing or developing the ideas, but with offering a marketing and diffusion perspective on high potential topics. The results can assist in deriving promising strategies to transform value chains and change the status quo of legumes. The methodological frameworks of the articles, i.e., the transtheoretical model on farm adoption or the binding online auction on consumer behavior, add a methodological contribution to the literature. The methodological contributions can assist to understand multi-stage adoption process (Article 1, Excursus 1, Article 2). The theorists of adoption behaviour describe all processes as a multi-stage decision, e.g. Rogers or Prochaska (1997). The main findings are briefly summarized in the following. A few concluding remarks on the outlook for crop mixtures and legume products are added, which I sincerely recommend the reader to consider.

Article 1:A TTM adoption model for legume-cereal crop mixtures

The article provides a rare socio-economic analysis of crop mixtures. In western countries, the characteristics of adopters of mixtures have not been analysed before. In line with a number of ecologically beneficial practices, mixtures are not widely adopted. An overly small share of adopters can limit a statistical analysis, if adoption is to be analysed in the context of a sample that somehow resembles a general share of farmers. I reused an adoption measure that classifies farmers into groups of rejection, contemplation and adoption. The adoption measure, based on the transtheoretical model of Prochaska and Velicer (1997), holds value for marketing research on many practices that are only applied by a few innovators. The measure allows for an analysis of adoption characteristics in each adoption stage. The measure can reveal how many farmers are willing to try, but are still uncertain how to integrate the practice into the crop rotation or work flow.

After interviewing farm managers from all German states, I derived an overview on adoption characteristics with respect to legume-cereal crop mixtures. A substantial share of farmers (40%) refused to trial, while a different group (44 %) does not know how to approach the matter, but is generally willing to trial. They show a positive attitude, but may see hurdles or a lack of fit with other cropping agendas that they intend to pursue. The sample represents farmers specialized in crop cultivation with relatively large farms and an above average use of conservation agriculture practices, e.g., no-tillage, reduced tillage, or cover crops. The adoption of mixtures is significantly positively associated with the cropping of legumes, the application of reduced tillage, the application of cover crops and the ownership of land rather than leasing land. These characteristics can be used to target potentially interested farmers with information campaigns. The perception of technical barriers and the perception of the agricultural potential for crop mixtures limit applications in the agricultural sector. Farmers perceive uncertainty on the worth of ecological benefits and have diverse assessments of technical barriers involved. Additional research will need to improve the transparency of the costs and benefits involved to effectively face these concerns.

It remains to be seen whether new agricultural equipment will simplify the application of mixed cropping systems. Novel precision farming technologies have been invented. These technologies can

change crop management from a field to a plant basis. For example, the digitalization of agriculture enables the combination of soil and plant mapping with fertilization equipment in order to tailor fertilization to the needs of each individual plant in the field. Similar approaches are growing in number for the application of plant protection. Even new strategies to design unstaffed harvesting units are under development. These units can cherry-pick bunches of matured crops. A widespread adoption of such precision farming technologies would also lower the technical hurdles to growing crop mixtures. The mixtures require a cropping process that can account for the different needs of multiple crop types with respect to plant protection, drilling depth and so on. A management system for individual plants would require less effort to deal with a variety of crop types.

The current use of crop mixtures as livestock feed is a pragmatic approach to decrease costs involved. Otherwise, the post-harvest processing equipment needs to be upgraded in order to separate the cereals and legumes. Some farmers regularly feed the unseparated harvest to pigs and cattle. We (IMPAC^3) proposed to analyse the effects on weight gain in consideration of varying crop shares in the feed. However, the scientific field of animal nutrition seems to be heading in a direction of increased control over inputs. The estimation of weight gain delays based on varying crop shares has not sparked interest with the few animal nutrition experts that we talked to. Nevertheless, a practical discipline such as agricultural science can benefit from interdisciplinary approaches to breeding, agronomy and animal nutrition.

Article 2: An online auction for health and environmental claims on new legume products

Legumes are a rare research subject in consumer behaviour studies. Oparinde et al. (2016) have dealt with marketing interventions involving health messages on biofortified legumes, and Klemcke et al. (2013) have analysed the public image of legumes, but the regular health and environmental benefits of legumes have remained a topic too specific for marketing studies. Increasing the demand for legumes with health and environmental claims can be a fruitful path in lowering the environmental impact of human lifestyles through food consumption patterns. Article 2 estimates the added value of claims on mineral fertilizer, CO^2-emissions, protein and fibre content, combines to roughly 20 €-Cents (35 %) among potential customers.

To market the absence of fertilizers may not be a purely environmental benefit. It is plausible that some consumers have an interest in consuming food without fertilizer, due to a health concern that cannot be substantiated. Understanding and developing environmental claims holds a potential for legumes which is currently not utilized by food processors. The online auction presents a methodological approach that helps to implement experimental auctions at relatively low costs. It has generated believable willingness to pay (WTP) estimates from a large consumer sample. The online setting compromises few experimental characteristics and can keep most quality criteria of lab experiments which I have discussed. The consumer segments willing to bid more for legume products are consumers who do not perceive legumes as a promoter of flatulence. If breeding progress were to reduce ingredients that cause the flatulence or information campaign would target how food preparation can reduce flatulence, a larger share of consumers could be interested to consume more. The consumer segments with higher demand for peas do not fully overlap with the segment for chickpeas. The image varies between legume types. The potential to integrate legumes in different consumption settings should also depend very much on the legume type evaluated.

A few developments suggest a brighter outlook for legume consumption. The public increasingly recognizes the link between diets and health (Vecchio et al. 2016) and grows curious of the ecological footprint involved in certain diets. Vanhonacker et al. (2013) find about one third of consumers ready to reduce meat consumption in order to minimize their ecological footprint. A market for CO^2- labelling seems approachable. In life-cycle assessment, legumes are increasingly discussed as a plant based source of protein that should substitute for meat based protein (Harwatt et al. 2017). While it seems promising to market CO^2-advantages, it remains unclear, if a trustworthy system can be installed, where consumers can fully understand CO^2-equivalent information. Retailers, e.g. Tesco, have tried unsuccessfully to implement a CO^2-labelling strategy.

In addition, food trends, such as Logi, Gluten free or Vegan, all facilitate diets with a relatively high legume consumption. The increasing number of legume ingredients in processed products, such as lupine coffee or chickpea-chips, lead to new products that may appeal to consumers who are ordinarily unenthusiastic about legumes. During our project time (2015-2017), several legume pasta varieties have entered German retail chains, e.g., REWE and Edeka. In the beginning, legume pasta was a product with limited availability in Reformhaus or Alnatura. The adoption by larger retail companies was accompanied by a substantial price reduction compared to initial retailer prices. While the price gap between raw materials should not be the decisive factor in food processors' choice for wheat or maize and against legumes, the lack of a transparent bulk market creates additional costs for the identification of suppliers. The costs for sourcing legumes can be less transparent to decision makers prior to procurement.

Excursus 1 and 2: Rye in pig feeding and GMO's media relations

Excursus 1: Rye in pig feeding can be seen as a question of production economics. Breeders in the private sector pointed us to the situation of rye, because they could not explain from a business perspective why pig farmers are reluctant to use it. This implied a request for a marketing perspective, which fitted nicely with my work on adoption behaviour and crop patterns. The strengthening of the nitrogen regulations and concerns for water pollutants have enhanced the topic's relevance for the agricultural sector. We (the authors of excursus 1) found that relatively negative attitudes towards feeding rye start with relatively negative ones regarding cropping rye. We assume, rye has an image with farmers, so that the different assessments in feeding and cropping spillover and influence each other. Worse performance in the field is connected to perceiving more hazards in the feeding process. Furthermore, the suppliers of premixed feed components have a strong tendency to offer a low amount of rye in the mix. It remains unclear whether the suppliers are largely driven by the mind-set of their buyers, which then differs from farmers who mix components themselves, or if the suppliers have other reasons to keep the amount low. Farmers specialized in pig farming tend to consider rye more frequently, which might be explained by the time and information investments they dedicate to feeding task on their farm. Lastly, the study provides some indication that farmers of sows, female pigs for birthing, are especially reserved in using rye. They have probably the most sensitive feeding task among the pig farm branches, namely piglets, sows and rearing pig. Nevertheless, research has shown that rye is acceptable for the task and we make a case why rye can save input costs.

Excursus 2: The analysis of relationships among topics is still a rare approach in the field of media research. Media relationships offer implications for issue management strategies. It may also be that a related issue has substantiated concerns and influences views on a linked issue with less substantiated

reservations. I find GMO to be somewhat related to market concentration and intellectual property rights. News articles which reference these related topics mention GMOs in over 40 % of all cases, while articles with GMO content rarely mention these issues. Limiting the data to news articles which have a topic keyword in the headline confirms the results and provides some robustness. In conclusion, the media utilizes GMOs to increase the salience of related topics. Keeping the related topic in the media cycle might help to maintain the attention of antagonists.

If the seed sector continues to do business without consideration of how the public will perceive effects on related issues, the opposition to new breeding technologies will last. Frequent mergers and takeovers, e.g., the growth of Limagrain (Mammana 2014), can fuel public concerns. The discussion on private interests' efforts to patent life forms will likely remain of interest to antagonists and policy makers. The traditional intellectual property protection of new plant varieties grants competitors and public institutions the right to continue research with protected varieties, which increases the opportunities for progress. I also like to mention the few open access rights on seeds that have been filed and granted. In general, the optimal strength of IPR's is difficult to determine; for further discussion see Eaton et al. (2006). I have addressed the need for seed companies to invest in campaigns that justify to the public why we still need to breed new varieties. Such a campaign should also address the related concerns regarding mergers and intellectual property rights. In order to emphasize the public benefits involved in mergers and property rights, companies may need to adjust their current approach to generating revenues.

References - Introduction & Conclusions

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Further, I like to thank the RTG 1666 (Global Food) for the frequent exchange with other economists. Without the RTG's qualification program, the doctoral seminars and retreats, my work would have a significantly lower quality. Next, my supervisor (Prof. Spiller) has created a supportive chair environment. He has contributed research ideas and enabled good working conditions. Most importantly, he has found an approach to supervision that helped me to believe in my work.

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List of peer reviewed publications & conference presentations

List of peer reviewed publications

Dominic Lemken, Achim Spiller and Marie von Meyer-Höfer (2017) - The case of legume-cereal crop mixtures in modern agriculture and the transtheoretical model of gradual adoption - Ecological Economics 137 (2017): 20-28 (Elsevier)

Dominic Lemken, Mandy Knigge, Stephan Meyerding and Achim Spiller (2017) - The value of environmental and health claims on new legume products: a non-hypothetical online auction - Sustainability 9 (8): 1-17 (MDPI)

Dominic Lemken, Kristof Stolze, Stefan Clemens Wille (2017) - Welche Faktoren beeinflussen den Roggeneinsatz in der Schweinefütterung? - Gewisola Proceedings 2017

Dominic Lemken (2017) - GMO sets the stage for media coverage on intellectual property rights and market concentration - accepted in Journal of Agrobiotechnology Management & Economics (Agbioforum)

List of paper presentations at scientific conferences

Conference	Place	Date	Title of Abstract & Presentation
IFAMA (International Food and Agribusiness Management Association)	Aarhus, Denmark	19.06.-23.06.2016	"The re-innovation of mixed cropping – who's interested?"
IFSA (International Farming Systems Association)	Newport, England	12.07.-15.07.2016	"The re-innovation of mixed cropping – who's interested?"
ILS2 (International Legume Conference)	Setubal, Portugal	12.10.-14.10.2016	"The case of Legume-Cereal crop mixtures in modern agriculture"
DGG (Deutsche Gartenbauwissenschaftliche Gesellschaft)	Osnabrück, Germany	01.03.-04.03.2017	"Die Wirkung von Gesundheit und Umweltaspekten auf die nicht hypothetische Zahlungsbereitschaft für Leguminosenprodukte"
EMAC (European Marketing Academy)	Groningen, Netherlands	23.05.-27.05.2017	"The effect of health and environmental claims on a non-hypothetical willingness to pay evaluation"
Gewisola (Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaues e.V.)	Munich, Germany	13.09.-15.09.2017	"Welche Faktoren beeinflussen den Roggeneinsatz in der Schweinefütterung? Eine empirische Analyse von deutschen Schweinehaltern

Author contributions

The table summarizes the authors' contributions to the thesis. The order of names is set in consideration of the overall investment for each type of contribution.

List of authors by contribution type

Contribution	Article 1	Article 2	Excursus 1	Excursus 2
Conceptualizing and refining research ideas	D.L.[1], Marie v. Meyer-Höfer, Achim Spiller	D.L., Achim Spiller	D.L., Kristof Stolze	D.L.
Literature search	D.L., Mandy Knigge	D.L., Mandy Knigge	Kristof Stolze, D.L., Stefan Clemens Wille	D.L.
Creating research design	D.L.	D.L., Achim Spiller, Stephan Meyerding	D.L., Kristof Stolze	D.L.
Instrument construction and questionnaire design	D.L., Achim Spiller, Marie v. Meyer-Höfer	D.L., Mandy Knigge	Kristof Stolze, D.L.	D.L.
Statistical analysis	D.L.,	D.L.,	D.L.	D.L.
Collection and preparation of data	Marie v. Meyer-Höfer, D.L.	D.L., Mandy Knigge	Kristof Stolze	D.L., Mareike Decker
Interpretation of statistical analysis	D.L.	D.L.,	D.L., Stefan Clemens Wille	D.L.
Drafting Manuscript	D.L.	D.L.	D.L., Kristof Stolze	D.L.
Editing Manuscript	Marie v. Meyer-Höfer	Achim Spiller, Stephan Meyerding	Stefan Clemens Wille, D.L.	D.L.

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Curriculum Vitae

PERSONAL INFORMATION

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WORK EXPERIENCE

Since 05/2014 — PHD – Candidate

University of Göttingen, Department of Agricultural Economics and Rural Development

Design and monitoring of a scientific subproject in the project IMPAC³: socio-economic analysis of legumes and intercropping of legumes

Farmer and Consumer Studies

09/2013 to 01/2014 — Intern/Project Assistant

Kloepfel Consulting in Düsseldorf

To apply nutritional and agriculture expertise in different consulting projects for the food industry

Consulting - Procurement & Supply Chain Management

01/2013 to 04/2013 — Intern

GIZ (German Development Organization) i.e. African Cashew Initiative (http://aci.africancashewalliance.com/) in Ghana

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EDUCATION

2010 to 2013 — Double Degree Program

Master of Science Management, Economics and Consumer Studies, 8,5

Wageningen University & Research, Netherlands

Advanced Econometrics

Academic Consultancy Training

Master of Science Agriculture and Food Economics, 1,6

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Quantitative Techniques for Planning and Decision making

2007 to 2010 Bachelor of Science Nutrition and Food Science

Bonn University, Germany

Analysis of Agriculture and Food Markets

Basics of Nutritional Science

PERSONAL SKILLS

Mother Tongue(s) German

Other Language(s)

English Full professional proficiency

Oxford language Test: 92% (C1)

Dutch Basis Level

courses in different student associations (A2)

Teamwork and Communication Skills

I am an experienced team worker in my professional and personal life. I have often been in charge of motivating fellow sportsmen (licensed coaching and administration for Senior Basketball Teams, DJK-Suedwest Cologne 2008-2011, SC Weende Göttingen 2014-2016, Anopa-Project 2012) and I worked in interdisciplinary settings (e.g. IMPAC³-project 2014-2017), where the ability to exchange ideas across disciplines and providing supportive thoughts is key to achieve group goals.

Organizational and Managerial Skills

I look back on a few additional organizational and management tasks over the years:

▪ Event planning and committee work as: Basketball Supervisor at the Sport Association DJK-DV Cologne (5 years, 2006-2011)

▪ Execution of tutorial tasks at University Bonn (4 semester positions, 2008-2011)

▪ Supervision of children at Don-Bosco Melbourne, Australia (6 months, 2007)

▪ Preparation of events at KHG cologne (gap year, 2006)

Job related Skills	▪ Experience in carrying out a scientific project independently
Computer Skills	Excellent command of Microsoft Office™ tools
	Advanced command of Statistical software: STATA, SPSS, Smart-PLS, due to my working experience in the academic context
	Basic knowledge of IT-Programs such as HTML, Java Script
Other Skills	Presentation skills
	Cooking
	Slack lining (balancing)

Cologne, 15. November 2017

D E C L A R A T I O N S

1. I, hereby, declare that this Ph.D. dissertation has not been presented to any other examining body either in its present or a similar form.

Furthermore, I also affirm that I have not applied for a Ph.D. at any other higher school of education.

Göttingen, ...

.....
(Signature)

.....
(Name in block capitals)

2. I, hereby, solemnly declare that this dissertation was undertaken independently and without any unauthorised aid.

Göttingen,.....

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