Explaining market behavior of farmers - Findings from an experimental beauty contest game with different contexts

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Abstract:

The supply in a market can be interpreted as a result of expectations of market participants about the behavior of other market participants and about the demand. Thus, a production decision has the character of a beauty contest problem. In addition, society’s expectations may play a role in the production decision. We want to examine the decision-making behavior of farmers in three different, realistic scenarios: fungicide use, wheat production, and production of animal welfare-friendly meat. With an incentive-compatible beauty contest experiment, we show if and how farmers consider the behavior of other farmers in their own decisions. In addition, in an initial exploratory analysis, we examine the impact of different contexts and influencing factors on decision-making behavior. Initial results show that farmers take into account the behavior of other farmers, but seemingly misinterpret the other participants’ impact on their own outcome.

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Abstract
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Keywords: Beauty contest game; market behavior; decision-making; experiment

Introduction
With increasing concentration on the various stages of the value chain, the behavior of other market participants is becoming increasingly important for the own decisions of a market participant (Sexton, 2013). For an investor, it's not so much about his or her own assessment of the future, but more about anticipating what other market participants will do (Keynes, 1936). Such situations can be found in many areas of agriculture: the use of fungicides and the threat of resistance depend on how other farmers use fungicides. The price that can be achieved in the market depends on how high the supply is and how high the demand is. Expectations about it have to be formed.

The Keynesian beauty contest goes back to contests from newspapers. In these competitions, it was the task to choose the six most beautiful faces, which are chosen on average as the most beautiful faces. For the best participant there was a prize. The decision does not depend on one's own opinion, but on what one thinks of the average and whether one thinks to what extent other participants make this consideration (Keynes, 1936). The beauty contest or guessing game is a way to illustrate the behavior of the other participants directly in an experiment.
Previous research on the beauty contest is either basic (see, for example, Nagel, 1995 or Kocher and Sutter, 2004) or refers to the stock and financial markets (see, for example, Biais and Bossaerts, 1998). However, a large number of other (real-world) decision problems are fundamentally based on the structure of the beauty contest problem. An everyday example is the question of whether or not to follow a diversion recommendation in the event of a traffic jam due to a line overload. If all road users follow the diversion recommendation, staying on the jam route might be advantageous as the detour route is likely to cover a longer distance and then be too congested. Relevant for the decision is thus on the one hand the estimation, which advantages and disadvantages the alternatives basically offer and on the other hand, how the other participants behave.

In agricultural economics, there are a number of decisions with beauty contest structure. In addition to the examples already mentioned, for example, the hog cycle (Harlow, 1960) can be explained, at least in part, by the inadequate ability of pig producers to anticipate the behavior of other pig producers. Other classic examples of decision problems with beauty contest structure are the sale of agricultural commodities and the lease market. Previous experiments in agricultural economics often take the behavior of the other participants and different prices as given (see for example Espinosa-Goded et al., 2010 or Kunte et al., 2017). In our experiment, the participants have to make their own reflections on the behavior of the other participants. It can thus be determined whether and how a participant takes into account the behavior of the other participants in his decision.

In addition to the assessment of other farmers, the assessment of social expectations can also play a role in behavior in experiments. Process characteristics and product qualities are increasingly important to consumers (Sexton, 2013). Social desirability describes “[…] culturally acceptable and approved behaviors, which are, at the same time, relatively unlikely to occur” (Crowne, Marlowe, 1960: 354). Vanclay et al. (2006) discuss that social desirability influences the way farmers see themselves and others. In different contexts, social desirability could have different effects on farmers’ choices in an experiment.

In addition to assessments of other farmers, social demands may also play a role in the production decision. With the beauty contest we want to show how farmers decide and to what degree these considerations play a role. For this reason, we combine the beauty contest with different real contexts: wheat production, animal welfare-friendly meat production and fungicide use. We will first present a short literature review of the beauty contest. Subsequently, we present our
experimental design and we derive hypotheses. The evaluation of our first samples takes place afterwards. We conclude with a discussion of our preliminary results.

**Literature Review**

The beauty contest game is often used to investigate reasoning processes and bounded rationality. A player has to form expectations about the other players’ choices (Nagel, 1995). One of the most prominent examples for beauty contest studies is guessing game by Nagel (1995). In recent years, a large number of studies on the beauty contest have been conducted (for example, Nagel, 1995; Grosskopf and Nagel, 2008; Sbriglia, 2008, Bühren and Frank, 2012). In these studies, all participants had to choose a number from a closed interval (e.g. 0-100). The one closest to the average has won. In a p-beauty contest, the number is multiplied by a positive and predefined parameter p < 1 (e.g. 2/3). P-beauty contests are used to examine the depth of reasoning (Bühren, Frank and Nagel, 2012). The Nash equilibrium in p-beauty contests with p < 1 is 0 (Bosch-Domènech et al., 2002). One advantage is that the parameters and equilibrium choices can be easily varied. Besides its simplicity, it is a good illustration of decision making in financial markets. Both interior and (external) boundary equilibria can be used (Güth et al., 2002). In the classic game, only the winner receives a reward. However, it is also possible to reimburse all participants.

The participants can reason and behave differently: In the simplest case (zero-order beliefs), the participant randomly selects a number without considering the behavior of the other participants. In the second case (first-order beliefs), the participant assumes that the other participants behave randomly and chooses accordingly. In the third case (second-order beliefs), the participant considers the first-order-beliefs and possibly n-th-order beliefs of the other participants (Nagel, 1995). In most studies, (considerable) parts of the participants’ responses deviate from the theoretically optimal answer, 0 (Nagel, 1995; Grosskopf and Nagel, 2008; Sbriglia, 2008, Bühren and Frank, 2012). Because there is no choice between (real) alternatives with different characteristics and payoffs, p-beauty contests are indeed suitable to examine "depth of reasoning". However, they are not suitable to investigate (economic) decisions between alternatives.

As already mentioned, there are no contributions to the beauty contest in the agricultural economics literature. However, such knowledge about the decision-making behavior of farmers could provide important insights into the market situation. Accordingly, we try to map realistic situations in our experiment. To do this we modify the classical approach and supplement it with a decision between different alternatives. Our approach also provides important insights into the
behavior of farmers in decision-making experiments. Below we present the structure of our beauty contest and our experimental design.

**Beauty Contest Structure**

In the following, we describe a simplified example and the theoretical solution for decisions with the basic beauty contest structure. Imagine a situation with a number of producers \( n \) producing a product \( y \). They can choose simultaneously between two product variants, \( y_a \) or \( y_b \). Each producer can either produce one unit of \( y_a \) or one unit of \( y_b \). For this reason, the total production \( Q \) is \( n \) units. The amounts of \( q_a \) and \( q_b \) are the result of the decisions of all producers.

\[
Q = q_a + q_b
\]

Production costs \( c_a \) and \( c_b \) are equal for every producer and equal for both variants:

\[
c_a = c_b
\]

We assume linear price functions \( (p_i) \) with a constant parameter \( \alpha_i (\alpha > 0, \alpha > c) \) and a parameter \( \beta_i (\beta > 0, \beta < \alpha) \), which is multiplied by \( s_i \):

\[
p_i = \alpha_i - \beta_i s_i
\]

\( s_i \) is the share of a product variant in the entire production and can be calculated by the number of producers choosing a certain product variant divided by \( n \). This results in:

\[
s_a + s_b = 1, \text{ with } s_i = \frac{q_i}{n}.
\]

If all producers decide to produce \( y_a \), \( s_a \) is 100 % and \( s_b \) is 0 %. If 30 % of the producers choose \( y_a \), \( s_a \) is 30% and \( s_b \) is 70 % and so on. It follows that:

\[
p_a = \alpha_a - \beta_a s_a
\]
\[
p_b = \alpha_b - \beta_b s_a
\]

\[
= \alpha_b - \beta_b (1 - s_a) = \alpha_b + \beta_b (s_a - 1)
\]

For the sake of simplicity, we first assume \( \alpha_i \) and to \( \beta_i \) to be equal for \( y_a \) and \( y_b \). This means that price changes are caused by changes in the share \( (s_i) \) of a certain variant in the total production. With an increase in \( s_a \), the price of \( y_a \) decreases and the price of \( y_b \) increases.
The profit functions \((\pi_i)\) for a producer \(i\) producing either one unit of \(y_a\) or one unit of \(y_b\) are therefore:

\[
\pi_a = \alpha_a - \beta_a s_a - c_a
\]

\[
\pi_b = \alpha_b + \beta_b (s_a - 1) - c_b
\]

A schematic representation of the profit functions is shown in Figure 1. The alternatives’ excellence depends on \(s_a\), and hereby on the simultaneous decisions of all producers. The intersection of \(\pi_a\) and \(\pi_b\) represents a threshold \((s_{th})\) for the excellence of producing \(y_a\) over \(y_b\). This means, before the intersection, \(y_a\) has a higher profit and vice versa. To maximize individual profits, producers have to form beliefs about other producers’ decisions. If a producer assumes \(s_{th}\) not to be exceeded, he should decide to produce \(y_a\) and the other way around. However, under the assumptions made so far, both alternatives are equally attractive. Both profit functions have the same parameters and \(s_{th}\) is 50%. There are no reasonable arguments to favor either alternative. Because of this, there is no dominating decision strategy and it might be assumed that all producers make a random choice. Random choice can be referred to as zero-order belief. The odds for both alternatives would be 50:50.

**Figure 1: Schematic representation of profit functions of \(y_a\) and \(y_b\)**

\[s_a = \text{Share (\%) of } y_a \text{ in the total production}\]

**k-level beliefs**
The situation changes when comparing product variants with different $\alpha_i$, $\beta_i$ and $c_i$. $s_{th}$ depends on the one hand on the difference between $\alpha_i$ and $c_i$ and on the other hand on the parameter $\beta_i$.

First, we take a look at the parameters $\alpha_i$ and $c_i$ which both have the same effect on the profit functions. We change $y_a$ with another product variant, $y_c$. We assume $\alpha_c$ to be larger than $\alpha_a$ or $c_c$ to be smaller than $c_a$ (ceteris paribus). The larger the difference between $\alpha_b$ minus $c_b$ and $\alpha_c$ minus $c_c$ the larger becomes $s_{th}$ (see Figure 2 (a)). In comparison to $s_{th}$ between $y_a$ and $y_b$ (= 50 %)$^1$, different levels of $\alpha$ or $c$ for $y_a$ (now $y_c$) shift the threshold to $s_{th^*}$ in this example, to 80 %.

The same effect arises, if the parameter $\beta_i$ differs between the alternatives (see Figure 2 (b)).

We now change $y_a$ to a product variant $y_d$. If $\beta_d$ is smaller than the original $\beta_a$, the price of $y_d$ still depends on $s$. However, in comparison to the former $y_a$, the threshold ($s_{th^*}$) becomes larger, in this example, it is 80 %.

**Figure 2: Schematic representation of profit functions of $y_a$, $y_b$, $y_c$ and $y_d$ and thresholds**

![Diagram showing profit functions and thresholds](image)

$s_a = \text{Share (\%)}$ of $y_a$ in the total production

$y_c$ and $y_d$ seem to be more tempting than $y_a$, because the threshold is now higher than in Figure 1. Starting from his/her assumption that all other producers are risk-neutral zero-order belief profit maximizers (= making random choices$^2$), producer $i$ should choose $y_{c,d}$. In this case, producer $i$ displays a person with first-order beliefs.

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$^1 s_{th}$ in Figure 2 (a).

$^2$ The odds for both alternatives would be 50:50.
If all producers would decide based on first order-beliefs, all of them would choose \( y_{c,d} \) and \( s_{c,d} \) would be 100%. If producer \( i \) realizes this, he/she can base his/her decision on a second-order belief: under the assumption that all other producers’ decisions are based on first-order beliefs, producer \( i \) should choose \( y_b \). However, all other producers could anticipate this as well and would therefore also choose \( y_b \). This series can be continued up to the \( k^{th} \) level (see Table 1).

In order to make an assessment, a producer may consider how many players have certain \( k \)-order beliefs. For example, if the number of other producers is \( n = 100 \) and producer \( i \) assumes 50 producers to have zero-order beliefs, 25 producers to have first-order beliefs and 25 producers to have second-order beliefs, \( s_{c,d} \) would be 50% and according to the thresholds in Figure 2, he would choose \( y_{c,d} \).

**Table 1: Type of beliefs and choices between two alternatives \( y_b \) and \( y_{c,d} \)**

<table>
<thead>
<tr>
<th>Beliefs producer i</th>
<th>Choice of producer i</th>
<th>Assumption of producer ( i ) about other producers</th>
<th>Assumed choice of the other producers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero-order beliefs</td>
<td>Random (= 50:50 odds)</td>
<td>No beliefs</td>
<td>No beliefs</td>
</tr>
<tr>
<td>First-order beliefs</td>
<td>( y_{c,d} )</td>
<td>Zero-order beliefs</td>
<td>Random</td>
</tr>
<tr>
<td>Second-order beliefs</td>
<td>( y_b )</td>
<td>First-order beliefs</td>
<td>( y_{c,d} )</td>
</tr>
<tr>
<td>( k )-order beliefs</td>
<td>( y_{c,d} ) if ( s_{c,d} &lt; s_{th^<em>} ) or ( y_b ) if ( s_{c,d} &gt; s_{th^</em>} ) or random, if ( s_{c,d} = s_{th^*} )</td>
<td>( k-1 )-order beliefs</td>
<td>Depending on the composition of beliefs</td>
</tr>
</tbody>
</table>

The described examples shown in Figure 1 and Figure 2 are relatively abstract. However, real-world decisions might be more complex and producers might not be profit maximizers, but utility maximizers. For example, individually different production costs could lead to individually different profit functions which would result in individually different thresholds for the excellence of the alternatives. This might be taken into account when considering the behavior of other producers.

The same applies to risk attitude. If a producer assumes \( s_{th^*} \) is exceeded, he should choose \( y_b \) because of a higher profit. But, if he is risk-averse and not sure about his assumptions about the other producers’ choices, he might decide to produce \( y_{c,d} \) because of its larger minimum profit

\[ 50 \cdot 0,5 + 25 \cdot 1 + 25 \cdot 0 = 50\% \]
(see Figure 2 (a)). On the other hand, whenever somebody is absolutely sure about his assessment, risk attitude does not play a role, because in that case, it’s a decision under (subjective) certainty.

In addition to the risk attitude, which can play a role in all uncertain decisions, specific decision contexts could also influence decisions. For example, if a socially desirable and a socially undesirable alternative are available, people might not decide based on profit or risk-utility maximization. They could instead choose the socially desirable alternative.

**Agricultural Production Decisions**

In this study, we examine the agricultural production decisions on growing wheat with different product qualities\(^4\), producing meat with different process qualities\(^5\), and pesticide use\(^6\), as examples for (existing) problems with beauty contest structure.

The structure of the decisions on wheat and meat results from the same context as shown in the basic beauty contest structure. Individual decisions influence the supply quantity in the market segments for commodities with a certain quality and thus influence prices. In contrast, the beauty contest structure in decisions on pesticide use emerges from the threat of resistance formation against a certain preparation. Resistance formation, among other things, depends on how often a particular fungicide is used. In the following, the decision-making problems, the underlying assumptions and possible effects of the different contexts are described more detailed.

**Wheat and Meat and Production**

Decisions on product quality of wheat and meat influence the supply volumes in specific markets. Supply volumes have different price effects on specific markets. Some alternatives like wheat with (very) low product quality\(^7\) and meat with low process quality\(^8\) can be classified as mass products. For these products, we assume relatively small price effects caused by local or national supply changes. The opposite alternatives – high-quality wheat\(^9\) and meat\(^10\) – are niche

\(^4\) Hereafter referred to as wheat.  
\(^5\) Hereafter referred to as meat.  
\(^6\) Hereafter referred to as pesticide.  
\(^7\) Usage: food, feed and bio energy production; substitutes: other grains and mineral oil (energy).  
\(^8\) Usage: national and international consumption; substitutes: imported meat, other meat (e. g. chicken) or vegetarian food.  
\(^9\) Usage: food (especially baked goods); substitutes: none.  
\(^10\) We assume a relatively small market segment of consumers with willingness to pay for animal welfare (see for example Lagerkvist and Hess, 2010; Höhler and Kühl, 2017).
products. For these products, we assume relatively large price effects due to local (or national) supply changes.

According to this, other farmers’ decisions have relatively little impact on the individual payoff of the low quality options. In contrast, the effect of other farmers’ decisions on the high quality alternatives is larger. As in our example above, this creates different profit functions for the farmers.

In these examples, the beauty contest structure results from the (unobservable or simultaneous) behavior of market participants. The production of high-quality wheat and meat is tempting because of the chance of higher revenues. However, it is also riskier due to higher production costs and higher variable prices. The relative excellence of alternatives depends on how many farmers choose to produce commodities with a certain quality. Producing high-quality wheat or meat is advantageous if “not too many” other farmers make the same choice. In this case – shortage of high-quality products – producing high-quality products is favorable compared to producing low-quality commodities. Higher production costs can be compensated by higher prices and thus higher profits can be achieved. In the opposite case – oversupply of high-quality products – producing low-quality commodities is excellent, as the prices for high-quality products are not sufficient to cover the higher costs. Both decisions are marketing decisions. In the context of animal welfare-friendly meat, however, social desirability may also be an influence on the decision.

**Pesticide Use**

Fungicides are pesticides which are used to control plant diseases. Farmers can choose between relatively cheaper and more expensive preparations. Cheap fungicides are initially tempting due to the lower cost, but carry the threat of resistance formation\(^\text{11}\). If resistance arises, yield loss occurs despite the use of a (cheap) fungicide. Whether a resistance arises, among other things, depends on how often a particular fungicide is used. The more farmers use a certain cheap fungicide, the greater the threat of resistance formation. Although expensive pesticides are disadvantageous due to higher costs, they pose a smaller threat of resistance formation\(^\text{12}\). Again, the excellence of alternatives is determined by the behavior of other farmers. If “too many” farmers use a certain pesticide, the resulting resistance leads to yield loss exceeding the

\(^{11}\) Cheap fungicides often contain only one active ingredient. Because of this, resistance formation is more likely.

\(^{12}\) Expensive fungicides often contain several active ingredients. Because of this, resistance formation is less likely.
cost advantage over the expensive pesticide. To maximize profit, risk-utility or utility, it is necessary to form expectations about the effects on prices or resistance formation caused by other farmers' behavior. Doing this, all different types of other farmers' decision motives and orders of beliefs have to be considered.

In addition to the short-term impact of resistance formation (yield losses in a given production period) long-term disadvantages may also arise. Currently, only five groups of active ingredients are available to protect cereals against harmful fungi. If a resistance against an active substance group occurs, farmers’ decision space is limited in the future. As a result, prices for the remaining active ingredients could rise, so that resistance formation poses a long-term danger of higher production costs. For this reason, cheap pesticides are alternatives with greater (short term) payout variability. At the same time they are less socially desirable.

The mentioned decision problems are all based on the same structure. There are some alternatives which are relatively less affected by other farmers’ decisions and show moderate payoffs. And there are other alternatives with more varying payoffs depending on the behavior of other farmers. Nevertheless, there is a significant difference between the three decision problems. In the wheat context, there are no differences regarding the social desirability of the alternatives. In the meat context, alternatives with more varying payoffs (high-quality meat) are probably also more socially desired. In the context of pesticide use, it is the other way around. Alternatives with more stable payoffs are at the same time socially more desired. We therefore expect differences in decision-making behavior between the three decision problems in the experiment.

**Experimental design and data collection**

In our experiment, we use the decision problems outlined above as contexts: (1) growing wheat with different product qualities, (2) hog husbandry with different process qualities, and (3) pesticide use in crop production. In addition to the mentioned decision contexts, a control treatment with the same problem structure but without context is examined.

In real-world, farmers can choose between many alternatives\(^\text{13}\) and the respective benefits are gradually influenced to a varying degree by the other farmers’ decisions. Marginal changes in other farmers’ behavior result in marginal changes in payoff amount as a result of relatively

\(^{13}\) Examples from a European country:
Wheat: wheat is classified in least five quality groups.
Meat: animal-welfare orientated, conventional, regional or organic production.
Fungicides: In grain production, five groups of active ingredients are used in 21 preparations with single and 44 preparations with multiple active ingredients.
complex relationships between supply and demand (wheat and meat) or biological processes (pesticide).\textsuperscript{14}

In order to avoid overstraining the subjects and to exclude other influencing factors, we have simplified the task in our experiment in two aspects:

1. **Alternatives**

The task consists only of the choice between two alternatives (A and B). Alternative A represents the previously described low-quality commodities in the wheat and meat contexts as well as the expensive fungicide in the pesticide example. Conversely, alternative B stands for high-quality commodities and a cheap fungicide.

2. **Payoff**

The payoff on alternative A will not be affected by other participants' decisions. Regardless of how many people choose alternative A, the profit is 40 monetary units (Euro = €).

The payoff on alternative B can have two states and depends on the proportion of subjects choosing Alternative B:

I. If a certain threshold is exceeded, the payoff is low (20 €). This situation represents oversupply of high-quality wheat or meat and the appearance of a resistance to a favorable pesticide,

II. If a certain threshold is not exceeded, the payoff is high (60 €). This situation represents undersupply of high-quality wheat or meat and no resistance formation against a cheap pesticide.

For each context, two treatments are performed, differing in the thresholds ($s_{th}$) for the occurrence of case I or II in alternative B. These are $\geq 20\%$ (treatment 1, $s_{th1}$) und $\geq 80\%$ (treatment 2, $s_{th2}$) of participants choosing alternative B. $s_{th1}$ ($s_{th2}$) represents a market where a relatively low (high) supply of high-quality products leads to an oversupply or a fungicide with a relatively high (low) likelihood of resistance formation.

\textsuperscript{14} In the examples wheat and meat, market prices of alternatives are the result of relatively complex interactions between supply and demand functions. Marginal supply changes lead to marginal price changes. Fungicide resistances can be qualitative or quantitative. For qualitative resistances, there are two situations: Either there is a complete resistance and the fungicide is completely ineffective or no resistance occurs and the fungicide is completely effective. Quantitative resistances are partial and a fungicide loses its effect gradually.
Table 2: Payoff matrix for player i

<table>
<thead>
<tr>
<th>Player i</th>
<th>Alternative A</th>
<th>Alternative B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 20 % (&lt; 80 %) of players</td>
<td>≥20 % (≥ 80 %) of players</td>
</tr>
<tr>
<td></td>
<td>choose Alternative B</td>
<td>choose Alternative B</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>20</td>
</tr>
</tbody>
</table>

The payoff amount refers to one production unit and is derived from real values (costs and revenues). The calculation of the payoff amount is explained in more detail in the description of the decision situations. These explanations were also available to the subjects. This is supposed to create a high degree of realism.

In reality, decision results are influenced by the decisions of other farmers. Therefore, each treatment is performed with a relatively large number of 30 participants in a between-subject design. This means, the excellence of the alternative with variable payoff depends on the behavior of all 30 participants of a certain treatment. The participants are informed that 30 people participate. In each treatment subjects are confronted with decision contexts, which they face in reality. For example, only pig farmers are confronted with meat context. This ensures the external validity of the study.

Our Experiment contains eight treatments differing in decision context and thresholds (see Table 3).

Table 1: Overview of the experimental setup

<table>
<thead>
<tr>
<th>Context</th>
<th>Context Effects</th>
<th>Threshold ($s_{th}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group</td>
<td></td>
<td>$s_{th1} = 20%$ $s_{th2} = 80%$</td>
</tr>
<tr>
<td>Wheat</td>
<td>No Effect</td>
<td>n=30</td>
</tr>
<tr>
<td>Animal Welfare</td>
<td>Social desirability</td>
<td>n=30</td>
</tr>
<tr>
<td></td>
<td>Short-term effect</td>
<td>n=30</td>
</tr>
<tr>
<td>Fungicides</td>
<td>Social desirability</td>
<td>n=30</td>
</tr>
<tr>
<td></td>
<td>Long-term threat</td>
<td>n=30</td>
</tr>
</tbody>
</table>

Data on the numbers marked black have already been collected.
The experiment is incentive compatible. Twenty percent of the participants are drawn at the end of the experiment and win the sum they have earned by making their selection. The accompanying questionnaires were distributed after the decision-making task. As a result, the participants do not know that they will have the opportunity to explain their decisions. With this approach, we want to reduce distortions in response.

Hypotheses

Based on the above considerations, we formulate our first two hypotheses.

H1: The choice of alternatives in the experiment depends on the estimation of the proportion of other participants who have chosen alternative B.

H2: The choice of alternatives in the experiment depends on the height of the threshold $s_{th}$.

If both hypotheses cannot be confirmed, then it may be that the participant has not recognized the beauty contest problem. There are also various other influencing factors that are considered in the following hypotheses.

It is also possible that the risk attitude of the participants plays a role in the decision (see Von Neumann, Morgenstern, 1944). We assume that risk-loving participants tend to choose alternative B instead. They could do that even if they estimate that the threshold has been reached. In our questionnaire, we use a 8-point Likert-Scale to obtain a self-assessment.

H3: The more risk-loving a participant is, the more likely he chooses Alternative B.

Decisions are based not only on the prediction of the future but also on the confidence with which one makes these (Keynes, 1936). We assume that the decision is taken under quasi security if a participant is very sure about the behavior of other participants. If a participant is convinced that more than the threshold of the participants chooses alternative B, then he will, despite the risk-taking attitude, choose alternative A. In our questionnaire, we use a 8-point Likert-Scale to obtain a self-assessment.

H4: The more confident a participant is with the assessment of the behavior of the other participants, the less important is the risk attitude.
Based on the different contexts, we also formulate the following hypotheses. Due to the incomplete survey, we will not test these hypotheses below:

**H5:** If social desirability is relevant to the decision problem, then the participants are more likely to choose the socially desirable alternative for his choice.

**H6:** If an alternative causes long-term negative effects, then the other alternative is chosen with a higher probability.

A participant may not recognize the beauty contest problem or process the probabilities properly. Then he would look for the maximum possible payouts and choose Alternative B. Therefore, we asked what the reason for the choice was: maximizing (short-term) payout, avoiding risk or otherwise.

**H7:** The more important the payoff maximization, the more likely Alternative B is chosen.

In addition, the participants’ own experience with the two alternatives may play a role in the decision. This is another context effect: the choice of an alternative could be explained by the farmer’s own experience.

**H8:** If the participant already has experience with one of the alternatives, then he rather chooses the alternative with which he already has experience.

In addition to the factors mentioned above, the farm size, other sources of income, age, sex and training of the manager could have an influence. These are recorded in additional variables.

**First results**

The data collection was firstly carried out at an agricultural fair and will soon be carried out at an event organized by an agricultural advocacy group. So far, 90 participants have been interviewed.\(^\text{15}\) First, we show which alternatives the participants have chosen according to the context and the height of the threshold (see Figure 3).

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\(^{15}\) See Table 3.
In the comparison of the two contexts it becomes clear that in the case of fungicides alternative B was chosen much less frequently. Comparing the two thresholds shows that, with an 80% threshold in the fungicide context, B was chosen more frequently, but the number of those who chose B remains well below the threshold. This can be interpreted as an indication of the influence of social desirability or of the long-term negative effects.

The estimation of the behavior of other farmers shows an interesting phenomenon (Figure 4):

**Figure 3: Preliminary results for the selection of Alternatives**

In the comparison of the two contexts it becomes clear that in the case of fungicides alternative B was chosen much less frequently. Comparing the two thresholds shows that, with an 80% threshold in the fungicide context, B was chosen more frequently, but the number of those who chose B remains well below the threshold. This can be interpreted as an indication of the influence of social desirability or of the long-term negative effects.

The estimation of the behavior of other farmers shows an interesting phenomenon (Figure 4):

**Figure 4: Estimated proportion of other participants who choose Alternative B (within 20%-limit)**
Those who chose Alternative B in the 20% treatments did so, even though they mostly estimated that more than 20% chose Alternative B. On average, their assessment is even higher than the assessment of the participants who chose Alternative A. It remains to be seen if this result will occur in the other contexts as well.

In a binary logistic regression, we check which of the reasons given in the hypotheses have an influence on the decision. The dependent variable is the selection of the alternative (2 = Alternative B). The appendix contains the results on the quality of the regression. The tests indicate a good fit. Table 4 shows the results:

Table 2: Preliminary results of a binary logistic regression

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
<th>95% C.I.for Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated proportion</td>
<td>.039</td>
<td>.015</td>
<td>6.746</td>
<td>1</td>
<td>.009</td>
<td>1.040</td>
<td>1.010-1.070</td>
</tr>
<tr>
<td>Treatment Threshold</td>
<td>.183</td>
<td>.622</td>
<td>.087</td>
<td>1</td>
<td>.768</td>
<td>1.201</td>
<td>.355-4.060</td>
</tr>
<tr>
<td>(1 = 80%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk attitude</td>
<td>.441</td>
<td>.208</td>
<td>4.507</td>
<td>1</td>
<td>.034</td>
<td>1.554</td>
<td>1.034-2.334</td>
</tr>
<tr>
<td>Confidence</td>
<td>-.212</td>
<td>.194</td>
<td>1.193</td>
<td>1</td>
<td>.275</td>
<td>.809</td>
<td>.553-1.183</td>
</tr>
<tr>
<td>Constant</td>
<td>-4.294</td>
<td>1.372</td>
<td>9.802</td>
<td>1</td>
<td>.002</td>
<td>.014</td>
<td></td>
</tr>
</tbody>
</table>

Hypothesis 1 is confirmed by the estimate. The estimated proportion of other participants influences the selection. In our case, a higher estimate means that the probability of choosing Alternative B increases. However, the line with the odds ratio (Exp (B)) indicates a very small effect. Hypothesis 2 cannot be confirmed for the time being. The threshold has no significant influence. Given the descriptive statistics, this is not surprising. Hypothesis 3 can be confirmed for now. The higher the risk-taking attitude, the more alternative B is chosen. The odds ratio shows a comparatively high effect size. The amount of confidence does not seem to influence the probability of selection. Nonetheless, it shows that more insecure participants have chosen alternative A more likely. The different signs of risk attitude and confidence tend to support hypothesis 4. If we estimate a single model for the wheat context,\textsuperscript{16} then we can also show that the experience with a particular quality group has a major impact on the choice of alternative.

\textsuperscript{16} Not reported.
With the collection of the other treatments and stories we hope for further insights. This applies in particular to the context effects, which were not explicitly examined here. In addition to logistic regression, we will apply further, multi-level analysis methods.

**Conclusion and Discussion**

We started the introduction with the observation that many decision problems can be traced back to beauty contest problems. This also applies to agriculture, where the conclusion on the behavior of other market participants is becoming increasingly relevant. However, this type of problem has not been studied here. Previous studies on the beauty contest deal very generally with the problem or relate to the financial market. In addition, the expectations of society play an increasing role in production decisions in agriculture. We explained the basic structure of the beauty contest and subsequently adapted it to decisions in agricultural production. From the existing literature we have derived different hypotheses. In addition to the assessment of the proportion of other participants who choose Alternative B, the height of the threshold, the risk attitude and the confidence with the own assessment thus play a role.

We perform an incentive-compatible experiment and use a between-subjects design. Our experimental design includes eight different treatments, each with the same payouts. In addition to two control groups for the two thresholds, there are three different contexts: fungicides, wheat and animal welfare. We suspect various context effects that we have not been able to test yet. However, the first results already suggest a context effect. Although the amount of payments was the same for all three treatments, the fungicide context always has a lower percentage for Alternative B. The remaining data to test these effects will be collected in early 2018.

In a logistic regression we test the four hypotheses about decision behavior: assessment of the other participants, height of the threshold, risk attitude and confidence. We find out that the assessment of the other participants has an impact on the participants' own decision. The probability of choosing Alternative B increases with participants' own assessment of how many other participants choose Alternative B. This is counterintuitive to the above theoretical comments on the beauty contest. First, however, it coincides with the behavior in reality, such as the hog cycle or the overproduction of milk in the EU after the quota has ended. Secondly, it clearly indicates that not only the assessment of the other participants is relevant. It turns out that especially the risk attitude determines the own choice of the participants. The confidence with their own assessment of the other participants and the selected threshold has no effect. The investigation of the wheat context shows that the experience with an alternative can play a role in the decision.
Our preliminary results show that the assessments of other farmers are included in the decisions made in the experiment. However, the direction of the sign suggests that the influence of other farmers on the market result is misjudged and/or the beauty contest problem is not recognized. This gives rise to the possibility of strengthening the knowledge of market mechanisms with the help of advisory services. For the research, it again shows that the results are very context dependent and that context effects should not be underestimated.

Our game is a single choice task. In reality, learning effects can occur. However, because our experiment was only attended by participants who make exactly these decisions in reality, these effects should be neglected.

References


Appendix

Table A1: Model Summary binary logistic regression

<table>
<thead>
<tr>
<th>Step</th>
<th>-2 Log likelihood</th>
<th>Cox &amp; Snell R Square</th>
<th>Nagelkerke R Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>76.742a</td>
<td>.163</td>
<td>.254</td>
</tr>
</tbody>
</table>

a. Estimation terminated at iteration number 5 because parameter estimates changed by less than .001.

Table A2: Hosmer and Lemeshow Test

<table>
<thead>
<tr>
<th>Step</th>
<th>Chi-square</th>
<th>df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8.964</td>
<td>8</td>
<td>.345</td>
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</tbody>
</table>

Table A3: Omnibus Test

<table>
<thead>
<tr>
<th>Omnibus Tests of Model Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Step 1</td>
</tr>
<tr>
<td>Block</td>
</tr>
<tr>
<td>Model</td>
</tr>
</tbody>
</table>