

***Dutch Farmer's Perspective and Practice on Satellite Data Systems
in northern Gelderland***

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Abstract

This bachelor thesis covers research on which factors influence the adoption of satellite data systems by Dutch farmers in the northern Gelderland region. In a time in which precision agriculture becomes more important through legislative sustainability goals, systems of innovation are deemed necessary for farmers to reach the set expectations by governments. These systems could moreover assist farmers in reaching more perceived benefits, therefore contributing to farmers self-sufficiency as well as the (surrounding) environment. Next year, a new satellite capable of improved crop monitoring will be launched, therefore more and more satellite data systems will become available through current years.

Nevertheless, actual adoption of these technologies seems to be absent. This study focuses on explaining the gap between potential and practice by combining three theoretical frameworks: the Unified Theory of Acceptance and Use of Technology (UTAUT), UTAUT2 and TAM2.

The methodology consisted of qualitative research with a diverse respondent group of farmers. The respondent group varied in characteristics and conditions. Age, farm size, farming discipline (arable, livestock and biological), education and level of experience with technology. The research design had multiple phases. Within semi-structured interviews, respondents were first questioned on their current perception of adoption variables to set a baseline. By use of an experiment, one of the variables, understandability, was tested and influenced. For the experiment new software was developed capable of retrieving, processing and visualizing satellite data. After the experiment, respondents were asked the same questions as before the experiment. More than 600 codes were obtained and combined into group codes through hybrid coding. These group codes were based on adoption values stated by UTAUT, with the addition of the UTAUT2 variable Price Value. After conducting group codes, patterns were interpreted abductively and relations between core adoption factors were identified: Expected Performance, Expected Effort, Social Influence, Facilitating Conditions, Price Value, Behavioural Intention, Usage Behaviour and Moderator Variables.

This research showed all respondents were currently not using the system. Usefulness was the key variable influencing willingness to use the satellite data system. The experiment in combination with interview results showed lack of usability and understandability influencing respondents into lowered perceived possible benefits and practicability, ultimately leading to unwillingness to use the system. Through the addition of support and infrastructure, the research showed possibilities of increasing usability and understandability leading to an increase in perceived benefits and usefulness. An increase in expected benefits and usefulness led to respondents being more willing to adopt and utilize the system. Thereby proposing an influence of support and infrastructure on behavioural intention. An increase in behavioural intentions results in usage behaviour.

In addition, it was deemed that present usage behaviour of others would nudge non-users into more willingness to use the system. Therefore it is proposed that positive social influence contributes to an increase in perceived usefulness, thereby increasing perceived performance benefits and willingness to use. Ultimately more willingness to use will result in more adoption and utilization of the system, reinforcing the feedback loop through social influence again.

Thus, current lack of use could be explained through a lack of insight in the systems usage and capabilities. By further development of the system through reduction of perceived use complexity and the addition of expert based advice farmers might become more willing to adopt the systems.

Observed relations were interpreted through abductive analysis, therefore not proven causal. Through further quantitative research with increased sample sizes, observed patterns might be deemed more valid and reliable. Then proposed relations may potentially be generalized and extended beyond the boundaries of the current respondent group.

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1. Introduction

1.1 Context

In 2026 the European Space Agency, ESA, is scheduled to launch a new satellite called 'FLEX'. It will be capable of measuring almost directly photosynthesis from above the atmosphere, therefore giving more direct insight on our earth and the way we shape it (Kramer, 2022).

The new satellite launch contributes to the trend of more and more data obtaining technologies being available to assist farmers in their agricultural businesses. Formerly launched satellites, 'Sentinel-1' and 'Sentinel-2', are already capable of delivering agricultural data, both open source. These satellites deliver vast amounts of datasets, making farmers able to predict and control their crop cultivation in a more data-driven manner. These datasets are accessible in the form of maps. With data being collected through a variety of satellites and through multiple timeframes, farmers are able to observe a wide range of information on their crops. For example, maps are able to show farmers the following, as stated by Kempenaar et al. (2018):

- a. Early signs of crop stress within their crop fields, making them able to intervene before damage is irreversible.
- b. Irrigation irregularities within their acres, making them able to change their irrigation patterns for a better distribution of water, resulting in a more sustainable manner of irrigation.
- c. Crop development and harvest predictions, by using harvest data of former years combined with the current growing state of a farmer's crops.

All giving possibilities for early intervention leading to more efficient and environmentally preserving ways of agriculture. **Yet, previous research concluded usage of data driven agriculture to be both an opportunity and a challenge for farmers.** Lack of understanding, high costs of implementations and limited availability of services lead to backlog within the agricultural sector (Vandercammen, 2020). All while successful implementation will lead to better optimized crop cultivation.

1.2 Urgency of research

Kros et al. (2024) concluded in their research current agricultural activities result in environmental problems through excess ammonia overflow and greenhouse emissions. To comply with European sustainability goals, use of new implications will be necessary to achieve stated targets. In research conducted by Ali et al. (2025) importance of nitrogen reduction was underlined. Multiple solutions were stated, under which 'smart fertilization'. Through precise allocation of fertilizer, unnecessary nitrogen use can be prevented, contributing to better sustainable agricultural practices.

Thus in the current time frame better allocation of resources to prevent overuse and spill is deemed necessary to achieve sustainability goals. Since satellite data systems could help farmers monitor crop health and deliver more support for precise resource allocation, it is expected these systems could possibly contribute to reduction of environmental strain.

1.3 Research questions

Thus, technologies capable of measuring and processing vast amounts of remotely sensed data are already available in different services. With more innovation on the horizon, it is important to understand both challenges and opportunities within acceptance as a result of these new innovations. To maximize its benefits. These new technological developments move fast, therefore rapid change within influenced fields of work require adaptation by its workers. Even though developments might be overwhelming and daunting for workers within these fast developing fields, it is necessary to consider using them.

What these challenges are and how to possibly overcome them is the aim of the research; to dive deeper into the acceptance of technological remote sensing implementations within Dutch agriculture. It is to be answered which factors drive farmers implementing or restraining from remote sensing data driven agriculture. For this research the following overarching research question is set to be answered;

Main-RQ: *Which factors influence the current adoption and utilization of satellite data systems for Dutch farmers in the northern Gelderland region, and what factors influence successful implementation?*

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To answer the main research questions it is important to form a clear view on the current situation within the agricultural domain. These context factors might influence the adaptation and utilization of satellite-data driven precision agriculture. Therefore the following subordinated research question will be used to examine the current state of satellite-data driven agriculture:

Sub-RQ1: *To which extent do Dutch farmers in the northern Gelderland region currently adopt and utilize satellite data systems?*

—

In addition, it is necessary to understand the current knowledge on which a farmer might base their view on the uses of satellite-data in agriculture. The research is qualitative, therefore goes deeper in understanding root causes and possible biases influencing respondents towards their views and choices regarding satellite-data driven agriculture. With the following subordinated research question, the aim is to uncover the viewing angles of a farmer . This will help understand issues causing withdrawal from implementing new technologies.

Sub-RQ2: *Does perception, based on prior based knowledge, influence farmers intention to adopt and utilize satellite data systems in agriculture?*

—

After answering the first two subordinated research questions, the following question is formulated to find out new ways to improve the adoption and influence of satellite data

systems in the agricultural sector. Finding possible barriers which might restrain farmers from implementing the innovation of satellite data systems and finding possible solutions for tackling these factors.

In other words, based on previous sub-research questions, which solutions for a more successful implementation and utilization of satellite data systems are deemed to be necessary by Dutch farmers?

Sub-RQ3: Through which measurements can Dutch farmers in the northern Gelderland region be supported in adopting and utilizing satellite data systems?

1.4 Relevance

1.4.1 Societal relevance

Identifying problems and opportunities in satellite-data driven agriculture is the first step of developing new strategic methods of agriculture, leading to higher levels of efficiency and better health for consumers. Next to that, a better understanding of human actions within agriculture might lead to a more environmentally preserving way of farming (Vandercammen, 2020). To understand why progressively implementing these new innovations contribute to overall societal welfare, it is important to first understand the influences of agricultural work.

The 'Sociaal-Economische Raad' (2008) stated agricultural processes result in externalities on multiple scale levels, from local to mondial. For example, progressive changes in agricultural labor will lead to more efficient ways of farming, therefore resulting in a better preservation of the environment. In addition, on national scale levels, governments stimulate education and innovation to help farmers compete within the economy. Competition leads to more efficiency and therefore increases food security and welfare.

This research focuses on understanding possible lack of education or other measurements to help farmers use new technologies contributing to more efficient and preserving ways of farming, resulting in an overall better societal welfare.

1.4.2 Academic relevance

Different theoretical frameworks are often used to understand the implementation and utilization of new innovations. Regarding these theories, later to be discussed within the paragraph 'literature study', there are vast amounts of possible factors contributing to usage of new technology. This research contributes in different ways to existing theories.

First, innovation takes place in different sectors, each with different goals and users. Therefore, one theoretical framework might deliver different results depending on the sector it is projected on. This research will set apart new data specifically within the domain of satellite-data usage within the Dutch agricultural sector.

Second, testing existing theories within new domains might result in underscoring current theoretical frameworks. Or, when not in line with existing theories, possibly forming new viewing angles within current theoretical frameworks. In that case, this paper contributes to existing theoretical frameworks by adding new findings to already existing theoretical frameworks.

Third, the amount of research on acceptance of satellite data systems within agriculture is very thin. Most existing research is performed in non-European regions. Therefore, this study might fill in a small portion of the theoretical gap within this domain.

2. Theoretical frameworks and literature

For this research, multiple domains of literature are deemed to be necessary for conducting a successful research. In this paragraph theories suitable for this research are elaborated upon. It is important to understand theoretical frameworks explaining the implementation and utilization of new innovations by its users. This theoretical domain is most important, as it will be the main framework used to explain the acceptance of satellite data systems by Dutch farmers.

2.1.1 Technology Acceptance Model (TAM)

First a theory named 'Technology Acceptance Model (TAM)' originally written by Davis (1989) was looked into during literature study. The theoretical framework covers individual acceptance and embracement of technology through two key factors:

- a. '**Perceived Usefulness**' (**PU**), does the participant use innovative technology or not? To what extent do they believe the new technology could contribute to better job performances within their domain?
- b. '**Perceived Ease of Use**' (**PEOU**), does the participant regard the new technology to be implemented by ease?

The conceptual model suggests design features of an innovation influence through cognitive response, the perceived usefulness and the perceived ease of use. In addition, perceived ease of use influences perceived usefulness. Therefore reinforcing the importance of well designed features within innovation. The cognitive response of an individual, thus both PU and PEOU, directly influence affective response, also described as Attitude Toward Using. Attitude of individuals leads to behavioral response of implementation and practice of innovation. The framework is, in comparison to others, quite simple. Using two key factors to analyze innovation acceptance, therefore limiting predetermined factors for research.

2.1.2 Examples of Technology Acceptance Model (TAM)

The TAM-model has been widely used since its creation. Recently, in 2024, researchers used TAM to create a new acceptance model based on TAM, the implementation of a satellite-based hydrometeorology early warning system in Indonesia (Prihanto et al., 2024).

In the discussion the researchers mentioned TAM was never used before for creating an acceptance model for satellite-based hydrometeorology. Citing multiple other researchers, Prihanto et al. state the original TAM-model is not specific enough for the innovation, while other extended versions of TAM are based on other innovation domains, therefore limiting the practicality for using it within satellite-based hydrometeorology. Therefore Prihanto et al., like others, decided to extend the original TAM-model to their research-relevant domain. It can be concluded that the original TAM-model therefore is generalized, but therefore leaving space for researchers to add more domain-specific factors into their factors contributing to a better understanding within the domain on which innovation is to be analyzed.

In addition, the research was recently conducted in 2024, therefore possibly giving more weight to critical statements on TAM in current technological landscapes since the depth and complexity of technology has only advanced since the original development of TAM. This statement is reinforced by other cited researchers in Prihanto et al. 's work.

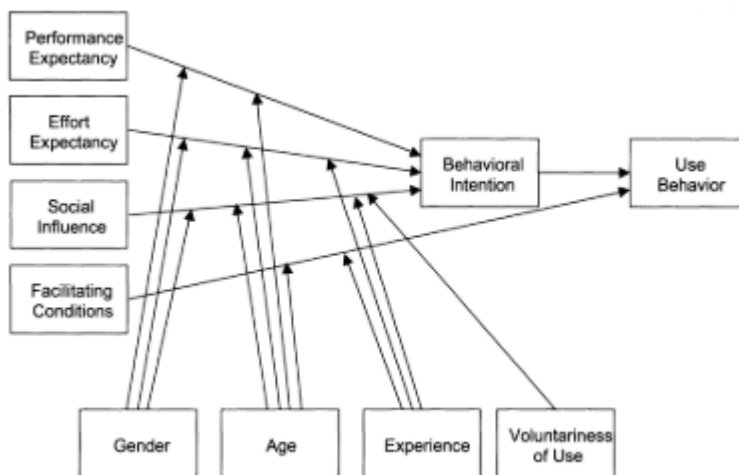
2.2.1 Unified Theory of Acceptance and Use of Technology (UTAUT)

Suggesting that TAM might be over simplified and outdated, it is decided to look further into more in depth acceptance models. Venkatesh et al. developed in 2003 a theoretical framework based on eight previously developed models including TAM. Their further-developed framework is named Unified Theory of Acceptance and Use of Technology (UTAUT). Previously researchers extended TAM, but Venkatesh et al. succeeded in making an extended and generalized version of an acceptance model taking key concepts of TAM and adding more important influencing factors to it. Since it's generalized, it is more insightful right out of the box, while still leaving room for researchers to add specific domain related factors to the model. Giving a wider view on the cases studied.

UTAUT is based on four key factors:

- a. **'Perceived Expectancy' (PE)**, based on the original TAM-model (Davis, 1989) key factor *Expected Performance*. The factor covers to what extent an individual is convinced new technology brings new advantages to their job.
- b. **'Expected Effort' (EE)**, based on the original TAM-model (Davis, 1989) key factor *Perceived Ease of Use*. This UTAUT-factor includes the view of an individual on the difficulty of using an innovation.
- c. **'Social Influence' (SI)**, additional factor to cover the social surroundings of a participant into the overall acceptance model. People are socially influenced in our decision making. For example neighbours, colleagues or even competitors can influence our Behavioural Intentions and therefore be an incentive or inducement to usage of technology.
- d. **'Facilitating Conditions' (FC)**, additional factor to include an individual's view on the presence or absence of systematic and organizational infrastructure in the field of innovation.

Figure 1, UTAUT-model



Venkatesh et al. (2003)

These four key components are shown in the acceptance model above. All four key components influence the Behavioural Intentions of an individual. These Behavioural Intentions incent or induce usage of technology. In addition, Facilitating Conditions contribute

directly to an individual's ability to use technology, therefore possibly prohibiting an individual from using an innovation despite their willingness to use it.

Underneath the key factors, moderator variables are stated. These variables influence relations between the key factors and the output variables 'Behavioural Intention' and 'usage'. These moderator variables are not obliged to use, but they give a broader interpretation of observed relations. Examples shown in the acceptance model above are 'gender', 'age', 'experience' and 'voluntariness of use'. These are frequently present in condemned research using the model. Researchers are, in similarity with TAM, adding more components to the UTAUT-framework.

2.2.2 Examples of Unified Theory of Acceptance and Use of Technology (UTAUT)

UTAUT is effectively used in research into consumer acceptance of GNSS-systems. (Moret-Talay, 2022). GNSS, in short for global navigation satellite systems like GPS. Research is conducted over GNSS-systems implications through multiple different fields using UTAUT as a theoretical framework to. Researchers state the inclusion of moderator variables like gender and age contribute to a better understanding of the acceptance model. Results found these moderator variables do show statistical influences on GNSS-acceptance, despite not all variables being significant enough to draw conclusions on. Therefore giving the researchers more insight in contextual moderator variables which contributes in developing a further fitting tool to measure the acceptance of GNSS in future research. Building further on previous research.

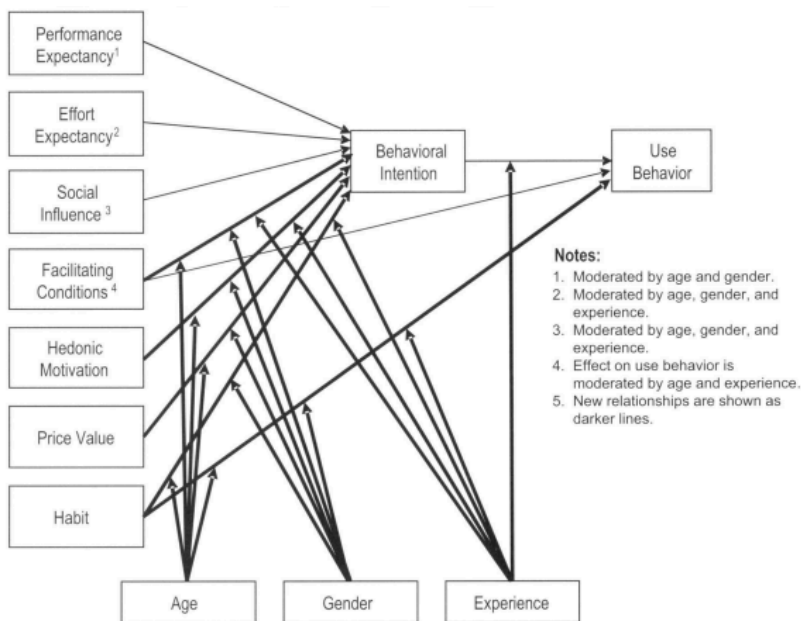
2.3 Unified Theory of Acceptance and Use of Technology 2 (UTAUT2)

In 2012 Venkatesh et al. developed an improved model of UTAUT. *UTAUT2* was developed as a more fitting acceptance model for consumer individuals, while UTAUT was based on organizational use settings.. In comparison to UTAUT, UTAUT2 includes three more key factors which explain more of the variation within *Behavioural Intention* within the acceptance model.

- a. **'Hedonic Motivation' (HM)**, this additional factor is defined as an individual's satisfaction and pleasure through (possibly) using a product.
- b. **'Price Value' (PV)**, including this factor, explains an individual's view on the economical pricing of a product or innovation.
- c. **'Habit' (H)**, defining the automatic structural innovation or product use of an individual through developed habits.

In the acceptance model (shown underneath) the relations between key factors, moderator variables and acceptance outputs are shown. It shows big similarities with UTAUT.

Figure 2, UTAUT2-model



Venkatesh et al. (2012)

2.4 Comparison of theoretical frameworks

In 'UTAUT AND UTAUT 2: A REVIEW AND AGENDA FOR FUTURE RESEARCH' written by Chang in 2012, both UTAUT and UTAUT2 are through literature research compared and evaluated. Chang states multiple papers through the year confirmed the importance of the four key factors of UTAUT contributing to '*Behavioural Intention*'. He also states Expected Performance is the biggest contributor of the four. Additionally Chang deemed UTAUT2 to be more explanatory for research results and variance. Therefore strengthening its importance for research use for acceptance modelling.

2.5 Importance of perception (TAM2)

A further development of TAM was made in 2000 by Venkatesh and Davis. On page 199 the following statement was made; '*We found that as individuals gained direct experience with a system over time, they relied less on social information in forming perceived usefulness and intention but continued to judge a system's usefulness on the basis of potential status benefits resulting from use.*'. Both authors state an individual's perception changes when experiencing an innovation or process directly instead of relying on others' experience through social influences. Within UTAUT and UTAUT2, this could be seen as a moderator variable named 'experience'.

2.6 Theoretical framework to be used

For this research on adoption and implementation of satellite data for agricultural practices by Dutch farmers, different models will be combined into one. TAM will not be used, but instead a combination of UTAUT, UTAUT2 and TAM2 are evaluated. TAM is deemed to be unnecessary because of its similarities with the first two UTAUT key factors 'Expected Performance' and 'Perceived Usefulness'.

UTAUT will be used as an acceptance model in combination with the key factor 'Price Value' of UTAUT2. It is decided to use UTAUT2 in addition to UTAUT due to 'Price Value' pushing the model into a more consumer-oriented role, fitting for Dutch farmers which are typically not within a bigger organizational structure. 'Hedonic Motivation' and 'Habit' are deemed to be inapplicable when farmers are not using innovation, therefore they are left out of the model to focus on key factors in play.

UTAUT moderator variables also deliver a better understanding of variation between respondents in the output of Behavioural Intentions. By combining UTAUT and UTAUT2, we get a more fitting model for this research case.

At last, 'experience' is in the UTAUT model seen as a moderator variable, therefore influencing relations between key factors and its outputs. It is suspected, based on TAM2, that (prior) knowledge and experiences (based on social influences) have a causal influence on key factors leading to adoption and use of innovation. In this research we will, in addition to the broad acceptance model, test this statement of Venkatesh and Davis (2000) on the acceptance model used for this paper. If experience and knowledge is perceived as an exogene causal factor influencing other key factors instead of a moderator variable, it might give new insight in reasoning for the current state of farmers' adoption and implementation of

satellite data for agricultural practices. This new insight could potentially give new directions to advisory in overcoming acceptance challenges within the domain.

2.7 Debate

Most of the models described above are mainly quantitatively used. This research is held qualitatively for two reasons;

1. Qualitative research gives more insight in reasoning and variation in responses. Deeper insight in key factors in play deliver a better understanding of Behavioural Intentions and usage of the respondents. With more qualitative data, a new quantitative measurement tool can be developed to gain validity in future research. More validity can be achieved by forming fitting questions for the respondent group.
2. By performing interviews, it is possible to intervene with the respondent. With a fitting intervention, the relation of (prior) knowledge and experience can be more efficiently tested. How this could be done will be discussed in the methodology.

3. Methodology

3.1 Research setup

Prior literature discusses theories on the acceptance of technology mainly through quantitative research, testing predefined relationships of variables. For this research broad interpretation of and understanding variance within key factors in play was more desirable than a larger quantitative methodology, since the goal is understanding of the variables. By first conducting qualitative research a better understandable and broader questionnaire can be developed, resulting in better validity.

Thereby it is chosen to conduct qualitative research. With interviews and integration of an experiment, research questions are set to be answered through data collection and interpretation. Qualitative results could lead to further improvement of questioning in future quantitative research, therefore improving possible consistency in respondents' answers.

3.2 Data collection

3.2.1 Interview-setup

Thus, interviews will be held with respondents within the field of Dutch agriculture. The interview will be semi-structured with open questions and dialogue between the interviewer and the respondent. The interviewing process will be structured as the following:

1. During the first phase of the interview contextual factors of the individual will be examined. Employment, business-category, business-context (like amount of acres and crops), age, gender, previous experiences and education level will be discussed. Within the acceptance model used for this research, these contextual factors will be seen as moderator variables.
2. The second phase of the interview reviews perception on key factors stated in the theoretical acceptance model (based on UTAUT and UTAUT2). This can be seen as a baseline measurement.
3. In the third phase, respondents were exposed to satellite data system use. Prior to the interview, satellite data of the respondents parcels is collected and visualized. During the experiment these visualizations are shown to the respondent. The respondent was asked to evaluate the results. It was tested if the respondent recognizes and understands features observed within the data. If not understandable, further context and information will be given by the interviewer. For further explanation of the experiment, see 3.2.3)
4. At last, during the fourth phase, after the experiment, the respondent will be asked the same questions asked in the second phase. Again, going over the key factors in play within the research acceptance model and discussing a possible shift in perception on the key factors. It is to be examined if the intervention leads to different perceptions on the adoption and implementation of satellite data in agricultural practices.

3.2.2 Respondentgroup

It was chosen to interview at least five individuals working within the sector to increase feasibility of conducting the research within the given time period. This restrained the research from being widely interpretable, but locally, in the region where these respondents operate, it would give a better insight into the acceptance of satellite data systems. These individuals were to be selected based on the following criteria:

- a. **Employment;** The respondents had to be active in the agricultural sector.
- b. **Land Use;** Respondents had to possess and be willing to provide the location of two parcels on which crops were cultivated. This was necessary for the experiment to succeed.
- c. **Disciplines of agricultural practice;** To ensure variance, different agricultural business categories were desirable to be interviewed. The aim was to include arable, biological and livestock farmers.
- d. **Business sizes;** Preferably, agricultural businesses of different sizes were included. Larger businesses might be able to spend more money on technological innovations, and therefore be more eager to innovate than smaller businesses with less possible spending options.
- e. **Crop types.** Different crop types might influence the need for data-driven agriculture. Livestock farmers tend to cultivate grass as a nutrition source for their livestock. Acre farmers and biological farmers economic models are deemed to be more lenient towards export of goods, therefore different financial incentives might lead to different perceptions on adoption and implementation.
- f. **Age groups.** For research purposes, diversity in gender and age was desirable, since technology experience is suspected to be more present with younger generations.

Respondent selection succeeded in finding employed farm workers with different disciplines of agricultural farming. The respondent group consisted of farmers with approximately 20 acres to 120 acres. Multiple different kinds of crops were also cultivated by these farmers. The ages of the respondents ranged between 22 and 55. All respondents were male. It would be best to also have included female respondents, but it was not possible in managing to find female respondents willing to participate in the research.

3.2.3 Experiment-setup

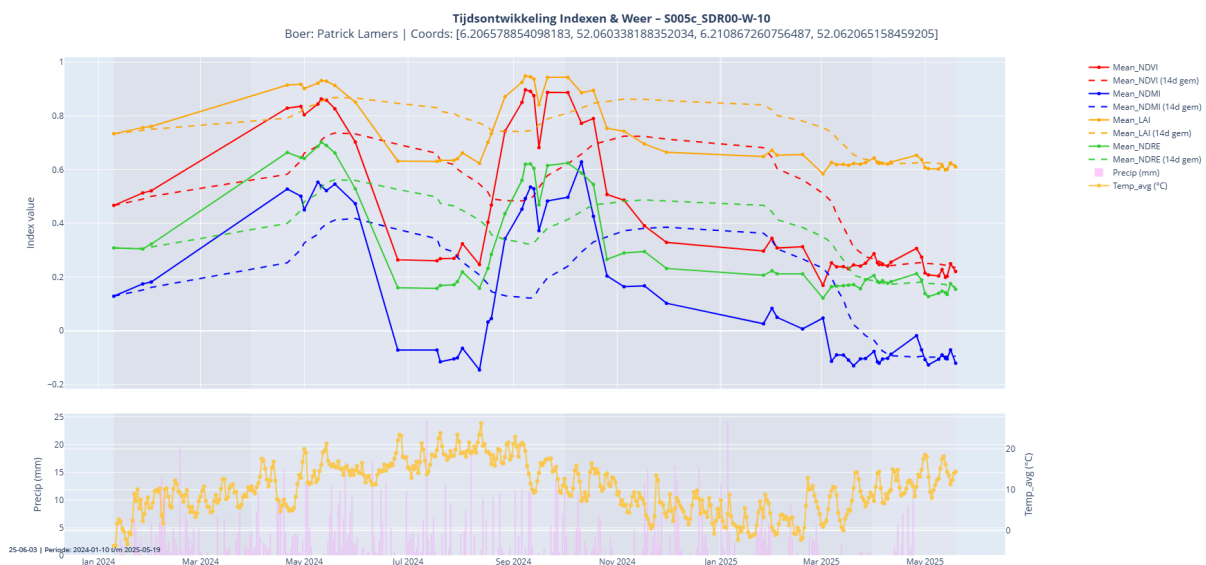
To measure the influence of experience or knowledge on other key factors an experiment was set up to be performed with the respondents. First a baseline of current perception factors was set during the second phase of the interview. Within the second phase respondents based their opinions on their own prior knowledge and experiences. Then, an experiment was performed in which satellite data about their parcels was visualized and discussed. The goal was to give the respondent a better view of usability of the innovation and its practices. After the experiment, during the fourth phase, the respondent is asked the same baseline questions as in the second section before the experiment.

Since available tools for crop monitoring by satellite data were costly or insufficient for the experiment, it was decided to create new software. For the experiment it was deemed

necessary to visualize farmer's field conditions through time. This is necessary for respondents to be able to possibly recognize their own field conditions, contributing to research results of usability alike systems. Therefore software was developed to obtain and visualize crop conditions based on satellite data about respondent's parcels. The software program was after initial development able to automatically:

1. obtain satellite data from Sentinel 2 within a given selected time frame;
2. select usable data through with a maximum amount of cloud coverage;
3. remove possible shadows and clouds from the imagery, thereby pre-processing data for further processing;
4. process image data into crop indexes;
5. visualize these indexes into an interactive dashboard able to be observed by respondents.

Development and use of the software resulted in software able to turn farmers' field conditions into graphs used in the experiment. In addition with a timelapse of the farmers field showing changes in crop conditions through time, the software was used to produce effective graphs used in the experiment.



Within the experiment data visualizations were presented similar to those provided by other current satellite data systems available on the market. Statistics included multiple indexes like; Leaf Area Index (LAI), Normalized Difference Vegetation Index (NDVI), Normalized Difference Moisture Index (NDMI) and Normalized Difference Red Edge (NDRE). In addition, weather information was presented underneath the graph for reference.

Respondents were asked to interpret the graphs as well as view the timelapses. First without assistance to measure current understandability, then with assistance to measure the possible change.

Developing software for this research was essential, but time consuming. It resulted in availability to measure the influence of knowledge and experience on other factors within the research model, through observance of possible change in respondents' answers before and after the experiment.

3.3 Data analysis

After performing interviews, recorded audio was transcribed. The qualitative data obtained through the semi-structured interviews and experiments were coded through a hybrid approach in which deductive as well as abductive elements were present. Using [Atlas.ti](#) the results were coded into two layers.

Within the first important statements of respondents were summarized into fewer words covering core values. Within the second layer, through **deductive coding** these values were linked to variables of the research model. In total 600 codes were divided into codegroups, often covering multiple groups. Important statements are presented in the results chapter within this thesis.

Through abductive analysis these codes were interpreted based on a combination of code groups, resulting in recognizable patterns. These patterns were then compared and interpreted through abductive analysis based on UTAUT-variables with inclusion of UTAUT2-variable Price Value.

4. Research results

Within this chapter research results are mentioned. Through interviews and coding the respondents' statements and behaviour were divided into core UTAUT and UTAUT2 variables. Many codes were tangentially related to multiple variables. Ultimately codes were stated below under the variable which most closely matched to the message of the code.

As mentioned before, the UTAUT2 variable Price Value was only deemed necessary for this research, therefore other UTAUT2 variables were left out. After presenting results of main adoption variables, interview findings covering output variables Behavioural Intention and Usage Behaviour are covered.

4.1 Expected Performance: perceived usefulness and practical benefits

Expected Performance (PE) explains perceived added value which (possible) users expect the innovation to deliver when in use. In this research it covers the extent to which Dutch farmers in northern Gelderland forecast adoption and utilization of satellite data to possibly be useful in increasing their efficiency and performance. Statements made by respondents range from positive to negative contributions of satellite data systems to expected performance.

Conducted interviews show expected **saving benefits** as a result of satellite data utilizations. Respondents stated satellite data could, through use of crop monitoring, improve their ability to precisely distribute their resources to areas of interest in need of intervention to maintain crop quality and yield.

In addition, more precise resource allocation might lead to an increase in **sustainability benefits**, lowering use of chemical pesticides and synthetic fertilizers. Less pesticide use would lead to less spillover of chemicals to surrounding areas, benefiting not only farmers, but also humans and nature.

Furthermore, respondents expressed that satellite data utilization could increase crop conditions and density through sooner observation of pests and diseases. This could result in increased quality and higher amount of crops per field, delivering **yield benefits** to farmers.

Also, utilization of satellite data could lead to **time management benefits** for farmers by better targeted area observations within their fields. Targeted observations could lead to an increase in more efficient decision making leading to the sooner and better anticipation (increasing other benefits) on crop issues.

At last, respondents speak of better strategic crop **planning benefits** based on comparison between different agricultural fields and taking account of coherent multiple variables. Better crop planning can be seen as a more efficient way of farming, resulting again in an increase in general benefits by decreasing potential crop issues.

Generally, they were positive on possible use cases.

4.2 Expected Effort: time, effort and overall understandability

Expected Effort covers expected ease of use whereby users are able to understand and efficiently apply innovations. In this case it indicates to which extent Dutch farmers from northern Gelderland perceive satellite data systems as intuitive, accessible and practical for their agricultural workload. Within this chapter it is to be discussed what observed sub factors contribute to the perception of Expected Effort.

All respondents stated **vast amounts of data** can be perceived as **overwhelming**. During the experiment all respondents observed multiple data indexes explaining different indications of the situation within their fields. This led to participants hesitating on possible interpretations, increasing needed effort for understanding and utility. Simplifying by limiting the quantity of data was deemed as a successful improvement of the service.

In addition, respondents noticed **complex data visualizations** limiting perceived ease of use. Respondents expressed maps and graphs too technical or abstract for practical use. Within the experiment it was needed to assist respondents in understanding and interpreting data. After explanation, data could partially be understood by respondents. Although, respondents did often not appear to be insightful enough to successfully convert data into practical decision making, indicating a lack of understanding of data as a result of complexity. One respondent stated that it *'is just too complicated for me'*, illustrating complex visualizations being too technical for understanding, therefore demanding too much effort to interpret, which the user might not be willing to deliver.

Vast amounts of data and complexity led to respondents expressing the presence of an **intimidating learning curve**. Without reducing different satellite data types and simple visualizations, participants stated the learning could be too intense for the largest group of possible users. Therefore, simplifying and reducing different data types would lead to an increase in willingness to use satellite data technology.

Difficulty of interpretation also led to an **increase in time and effort** needed to utilize the technology. This is in contradiction to the goal of the service, where in fact use of the service should support farmers in more efficient ways of farming. One respondent mentioned that he is *'not able to sit the whole day in front of the computer learning how everything works'*. With that the respondent underlined limited availability within time management, resulting in less willingness to use satellite technology.

At last, some respondents stated adoption and utilization of satellite technology would **disrupt** their **farming routines**. Respondents valued current farming routines wherein satellite data is not utilized to be efficient enough for their experience. In combination with effort needed to adopt the system currently within their routines, respondents mentioned to refrain from possible adoption of the technology. Thus, impacting willingness to utilize the technology.

In sum, multiple different aspects influence respondents' expected efficiency of satellite data systems. Amount of data, complexity of visualizations, existing routines and a steep learning curve might result in more time and effort needed, contributing to the general term of expected efficiency. Together, these elements influence perceived effort needed for adoption and utilization. **Given the current state of perceived ease of use, most respondents were not willing to use it.**

4.3 Social Influence: influence by social environments

Social Influences describes the extent to which other users are convinced by an innovation and therefore believe others should utilize it as well. In this case, it refers to the amount of exerted influence by other farmers utilizing (similar) technology on Dutch farmers within the northern Gelderland region. This chapter discusses observed sub factors contributing to the concept of Social Influence.

First, it is to be answered who is contributing to the general perception of Social Influence. Multiple respondents stated that they were working together with other farmers, most of the time **contractors**. Contractors perform a service for the farmers who hire them. It was noticed that contractors often were more willing to invest in innovation and had better specialized equipment. Respondents were positive about contractors' performances, but because of the contracting-construction, it was not currently deemed incentive to invest in the innovation most of the time. This also resulted in circumventing other pitfalls of technology use. Complications within ease of use were for example bypassed by outsourcing the utilization of the system to the contractors. On the other hand, these contractors could contribute to social influence by delivering farmers a more **direct line of sight** into the technology, as multiple respondents mentioned contractors using technological innovations in their direct proximity. It should be mentioned that these statements should be nuanced, since they were mostly based on the use of other technological innovations.

Moreover, respondents express possible influence by **neighbours** and **colleagues**. It would be only influential when others' experiences were extrapolatable to the respondents' business. **Similarity factors** like location, business operation type and crop usage were deemed necessary to understand and trust users experience by non-users. Respondents were more clear in the influence by this group of influencers, than by contractors.

In the respondents region, use of satellite data systems is not or hardly noticeable. Almost all respondents mentioned they were not in social contact with users of this technology. Respondents stated that in **other Dutch regions** using satellite data systems is more prevalent, because of external factors like soil prices and soil conditions pushing farmers in more proactive ways of farming using innovations. The lack of **similarity factors** and the presence of distance between the non-users and the users does not encourage adoption. One of the respondents stated 'if the neighbour uses it, then it suddenly becomes interesting'. Thereby referring to the importance of comparable farmers' experience.

Respondents estimate that in the future, it can be expected others will start adopting satellite driven data systems because of external factors like legislation leading to the necessity of more optimized resource distribution. It was stated that new legislation might result in some farmers slowly being more willing to adopt the system. When this happens, it is to be forecasted others will follow when use is proven to be effective and practical. One respondent gave insight into current social structures between farmers. Through regular meetings farmers discuss ongoing issues and methods together advising each other in their business operations. Successful future adoption of satellite system usage is expected to spread through these groups in a snowball-like effect.

4.3 Facilitating Conditions: presence and demand of support and infrastructure

Facilitating Conditions refers to the extent to which an individual is convinced necessary support and infrastructure is present within an innovation. In this study it specifically covers the degree to which Dutch farmers from northern Gelderland experience the presence of support and infrastructure needed to successfully utilize satellite data systems. Conditions deemed necessary for use can both cover physical as well as digital structures. In this chapter observed sub factors contributing to Facilitating Conditions are explored.

Respondents state current data driven technology can produce so named '**task maps**'. These maps are deemed important for practicality. It bridges the gap between data and practicality by transforming insights into meaningful actions directly within cultivation. For example, data could suggest upcoming plagues within a specific area of an agricultural field. Through use of task maps, farmers are able to calibrate advanced machinery to distribute resources variable based on area-specific needs. It was deemed to be of great importance to have satellite based systems able to produce these task maps to increase efficiency.

At the same time, all respondents mentioned they were not in the possession of **machinery** meeting the digital and mechanical levels of expertise needed for use of these task maps. Thereby it was noticed the respondents required the satellite data technology to be able to produce task maps for essential practicality as well as themselves be in ownership of more advanced equipment. Great cost of new equipment prohibited them from being willing to invest in new equipment suitable for use of satellite data driven task maps.

As stated in previous chapters, understandability of satellite data was to a certain extent present. Nevertheless, transforming provided data into practical actions was seen as too unreliable as well as time consuming to implement it by themselves. Almost all respondents were convinced by the involvement of an expert. Implementation of **expert-based advice** was deemed useful subject to one key condition; interpretation and advice should be based on an **interplay between the advisor and the user**. This way an expert could:

1. relief the user from having to interpret many measured data types, lowering farmers time and effort;
2. more reliably assess complex interdependencies between variables for effective anticipation;
3. take farmers' knowledge and visual observations of crops to the advisory table.

This way, by opening up a dialogue between expert and user, advice becomes more reliable and effective. Respondents state without interplay between user and expert, expert-based advice may lead to decreased quality and lack of acceptance by farmers. One respondent mentioned the importance of advisory support '*without [the expert] sitting in the chair of the farmer.*', underlining the need to preserve farmer autonomy within decision making.

Some respondents deemed the satellite data systems to be **widely applicable** to different types of farmers. Based on equipment, agricultural methods and price, different packages of satellite data support would be deemed to be sufficient. The technology should be applicable in different levels of support-packages. Not all packages should include expert-advice or deep integration between satellite data systems and equipment, because not all farmers are in need of expert-advice or in ownership of advanced equipment.

In addition, the importance of **self-learning systems** to reliably interpret and predict data to create advice was deemed to be necessary for successful use applications by one respondent. Through testing during **pilot development studies**, the system could be more accurately calibrated for broader use. Nevertheless, the respondent stated regional differences could lead to problems with calibration, signaling to trustability issues of the system. Therefore, the importance of extensive testing within different farming conditions was deemed necessary.

The respondent was ultimately positive on future developments, stating *'Once the ball of self-learning starts rolling, that ball suddenly rolls very hard and becomes round.'* Indicating self-learning development could lead to rapid improvement of the system and delivering results up to desired expectancies.

Multiple respondents also mentioned, through perceived insight through the experiment, **cloud coverage** resulting in time periods without data. These periods without data would disrupt the whole system of providing any use. Some participants mentioned compatibility with other services as a possible solution.

At last, respondents noticed one more external factor influencing practicality of the system, with no clear direct solution to. Within certain time frames, it is prohibited through **government legislation** to distribute certain resources on agricultural fields. For example, during water scarcity in dry periods, it is by law prohibited to irrigate on agricultural lands. These laws and governmental interventions limit the ability for farmers to anticipate on behalf of satellite data systems during certain time periods, influencing practicality. With legislation becoming more extensive, respondents were not hopeful for legislation to become less limiting.

4.5 Price Value: cost-return ratio

Price Value alludes to the ratio between monetary costs and returns of adopting and utilizing an innovation. Within this research case it covers the degree to which Dutch farmers from the northern Gelderland region perceive the trade-off between costs of and returns as a result of satellite data systems used for agricultural practices. In this chapter, contributing subfactors are explained influencing farmers' perception of cost-return ratios.

For the respondents it is necessary monetary returns of satellite data systems to outperform its costs. These costs of the system can be divided into two directions; **direct** and **indirect costs**. Direct costs of satellite data services were for most respondents not perceived as too excessive for good return, therefore ending up in a positive cost-return ratio. One of the respondents expressed '*good advice is never too expensive*', thus expressing practical advice that delivers more returns than it costs to obtain.

While the **direct costs** were not experienced as out of balance in regard to being too costly, the indirect costs directed respondents into an uncertain cost-return balance. As stated in the previous chapter, lack of advanced equipment limited users from optimal benefits. To increase possible monetary results by use of the system, almost all respondents deemed upgrading to more advanced machinery necessary.

All respondents who mentioned this also mentioned **indirect** costs of new machinery were deemed too high, outweighing direct monetary returns by adoption and use of the system. This also supports the argument of one respondent supposing different levels of provided support within the system. Providing different packages priced differently and without necessity to be integrated directly in machinery leads to the possibility of wanting to invest in the system by removing indirect costs and limiting direct costs. This could result in a bigger positive cost-return ratio.

At last, respondents stated use of the system could possibly increase their **revenues**. By increasing performance through better resource allocation, less resources have to be bought. In addition to possible increased crop yield and quality, the system could effectively increase revenue, thereby resulting in more desirable cost-return ratios.

4.6 Moderator Variables: characteristics and conditions

Certain factors seemed to influence farmers and their perception on other variables. These so named moderator variables are contextual, based on characteristics and conditions such as farm type, region, age, social environment and current access to resources. These characteristics and conditions do not directly influence use, but do shape how other core variables are interpreted and expectations are perceived.

Agricultural operation type was observed through respondents statements to strengthen or lessen their views. The respondent whose **cultivating methods** were based on biological farm guidelines mentioned other as well as fewer expected benefits. Biological farmers were less willing to intervene on their land and had less resources to distribute, therefore limiting expected performance compared to others. Arable farmers were most positive about expected benefits. Since they owned more fields and more different crops, monitoring of crops was often more expected to be useful because crop quality and amount were directly linked to more revenue. Livestock farmers were most modest, they were more traditional oriented and were more convinced of keeping current routines and methods of farming.

Other sub factors contributing to this moderator variable were **farm size, crop type and diversity**. These conditions resulted in respondents basing perception and expectancy on other variables. Bigger farms were often linked to different forms of crop cultivation, thereby increasing complexity of farming methods and an increase in time management importance. With a broader scale of crop types and often bigger farms, performance expectancy were deemed to increase more. Farmers with few fields often had less **distance** between and less different crops in their fields. Therefore resulting in less need of digital assistance through satellite data systems because it was easier for them to visit and observe their crops within a smaller amount of time.

Respondents also stated **regional factors** like soil types and acre buying prices influenced their perception on the importance and need of new technology. For example, expensive acre prices resulted in farmers being more willing to increase their revenues, therefore taking more risk with technology adoption. One respondent mentioned the Dutch 'Polder' region as an example of technological innovation being more adopted.

Another observed influential characteristic was the **age** of the respondents. Older respondents stated they would expect younger farmers to be more capable of understanding to use satellite data systems. One respondent stated a gap between younger and older farmers in technology acceptance and understanding. Younger farmers were raised with more technology in their environment, therefore more used to utilization of complexer technology. These statements were backed up by younger participants being more enthusiastic about the system based on its possible benefits, usability and applications.

Younger participants also mentioned more often they are following or followed recent **education** on agriculture. These days, agricultural education includes more technology adoption and utilization use cases. Moreover, within education respondents stated class groups brought new insights into other farmers' experiences on technology use. These respondents had more experience and knowledge of different technological agriculture systems than respondents who did not follow or followed education a long time ago.

At last, possession of **equipment** and earlier experience with adoption shaped farmers' perspective. Multiple respondents stated it was first necessary to fully adopt and utilize other innovations they were currently investing in. Also, current owned equipment was deemed enough for current practices, therefore fulfilling the needs of farmers.

4.7 Usage Behaviour and Behavioural Intention

As stated in UTAUT and UTAUT2, all other variables within the model influence output variables Behavioural Intention and Usage Behaviour. Behavioural Intention covers the willingness to adopt and utilize technology, while Usage Behaviour is a direct result of intention to adopt and utilize.

All respondents stated **currently not actively using** satellite data systems. It was stated systems were perceived as too complex for use with vast amounts of information making them difficult to use and interpret. Complex visualizations and lack of benefits for their agricultural methods were expressed.

Since the system given its current state was not perceived as easy to use and lacking possible benefits, respondents refrained from usage. It was stated **further development was needed** for potential of future adoption and utilization. Respondents suggested the technology should be better connected to the respondents by increase in usability and usefulness. Reduction of information intake, better grounded decision making through interplay between expert and farmer, self learning implementations to increase reliability and proven effectiveness through others were deemed necessary for willingness to use. All but one respondent deemed these **improvements were not directly on the horizon, therefore almost all stated not intending to use them for coming years.**

5. Discussion

In the discussion perceived patterns are mentioned and interpreted as proposed relations. Proposed relations were not causally proven, but formed through interpretative abductive coding and layering. UTAUT + Price Value was used for a base of discussion. Each subchapter is based on one core variable influencing others and includes observed patterns, moderator variable influences and a recommendation for further research. The chapter ends with a summary on interconnected interpretation of suggested patterns and a reflection.

5.1 Expected Performance

5.1.1 *Expected Performance interaction with Behavioural Intention*

All respondents stated willingness to use satellite data systems depends on expected beneficial outcomes of use. When adoption and utilization of the system has clear and positive contributions to current cultivation methods, trust in the system is increased. With increased trust in expected performance of the system, farmers willingness and readiness for the adoption is improved. In other words, Expected Performance influences Behavioural Intention.

5.1.2 *Contextual moderator influences on Expected Performance*

As mentioned in the results chapter, some contextual characteristics and conditions were observed strengthening or weakening relations of Performance with other variables. Within this subchapter context, characteristics and conditions influencing Expected Performance will be evaluated. Many moderator variables are possibly influencing perception on Expected Performance. Through the research factors like type and size of farm, cultivating methods, diversity of crops and equipment possession might be linked to the core variable.

Farms of greater scale had often more fields with different crop types to manage, therefore resulting in more time and resources demand for the farmer. Satellite data systems were perceived to result in more efficient resource allocation and time management, resulting in higher efficiency in general farming. Difference in cultivating methods by farm type influenced in intervention possibilities, therefore influencing practical use. At last, current equipment possessions influenced the extent to which farmers were able to use the service, therefore influencing the usefulness of the system. All moderator variables were observed to influence the variable Expected Performance.

5.1.3 *Intermediate reflection and recommendations*

In summary, it appears Expected Performance is related to other UTAUT-variables and contextual moderator variables. Although data suggests these relations, it is important to underline lack of causal proof. Through pattern interpretation of different codes and code layers, it is suggested the relations are present.

Through **further quantitative research** possible relations between Expected Performance and other variables can be validated. In addition, **future qualitative research** on moderator variables influencing perceived usefulness can broaden the picture of contextual, characteristics and conditions in play influencing strength between Expected Performance and other variables.

5.2 Expected Effort

5.2.1 Expected Effort influence on Expected Performance

Currently respondents noticed possible benefits by utilizing satellite data for their farming practices. Responses were every so often hesitating or negative on expected performance influences given the current state of understandability. Some expressed satellite data insightful, but **lacking clear guidance** in possible interpretation, therefore limiting farmers decision making. Perceiving the innovation as not practical enough for understanding and/or use. Without ability to anticipate by lack of understanding, an increase in performance is not expected, therefore limiting benefits of use. This suggests Expected Effort playing an influential role on Expected Performance.

Perceived ease of use seems to directly influence experienced possible benefits of the system. Respondents showed lack of knowledge and insight for the system's capabilities. Data interpretation is the foundation of effective decision making delivering benefits to its user. Farmers who find the system difficult to interpret are often not able to perceive possible decision making, resulting in the lowering of Expected Performance. In contrast, farmers who are able to understand and anticipate by utilization of the technology, are seen to see more benefits of use. This relation between Expected Effort and Expected Performance was directly backed up by the performed experiment.

Prior to the experiment respondents were interviewed on Expected Performance. After the experiment respondents were observed being more positive over possible usefulness of the system. During the experiment respondents were assisted in understanding provided data. After explanation of the data types and their influence on overall crop quality, the respondents were showing improved understandability. After an increase in understandability, expected benefits of the system were more often stated by the respondents. In combination with interview statements, these results of the experiment showed a clear influence of Expected Effort to Expected Performance.

Thus, understandability and ease of use seems to be the biggest influence on direct foundations of perceived effectiveness of the system. Through support and infrastructure, satellite data systems can be improved to increase expected performance. In addition, lack of social contact with other users of the system could possibly have influenced respondents' perception on its effectiveness.

5.2.2 Contextual moderator variable influences

In addition, there were moderator variables in play contributing to the strength of seen relations between Expected Effort and Expected Performance. (Prior) knowledge and experiences were most influential on the relations between Expected Effort and other variables. Previous experiences, good or bad, influenced perception on the difficulty of utilizing a new technology. Age was seen as another important moderator variable. Younger participants were more positive on the system's ease of use than older participants. Both categories underlined this relation. Moreover, respondents who (recently) followed farming related education were more positive on expected ease of use. This might be explainable

through respondents receiving more insight on others' perception of ease of use of technology, underlining also an influence of variable Social Influence on Expected Effort.

5.2.3 Intermediate reflection and recommendations

Even though an influence between Expected Effort and Expected Performance was noticed, validation is still to be achieved. Through **further quantitative research** the possible relation can be grounded as a possible causality. In addition, **future qualitative research** on moderator variables influencing perceived usefulness can broaden the picture of contextual, characteristics and conditions in play influencing strength between Expected Effort and other variables.

5.3 Social Influence

5.3.1 Social Influence influence on Expected Performance through Expected Effort

Respondents did not experience direct social influence on adoption and utilization of satellite data systems. Through (absence of) social contact with other users, respondents' abilities to understand the system are influenced. Farmers could obtain more insightful information about the system's ease of use through others' experiences. Therefore, increasing their abilities to comprehend the system. A relation between Social Influence and Expected Effort can be laid down, wherein others experiences with usability and comprehension shape the perceived efficiency of non-users.

This connection was further supported through observations. It was noticed that respondents who knew others who successfully utilized systems were more positive on expected ease of use. This was in almost all cases not satellite technology, but most of the time gps-system implementations. For example, a colleague's successful experience in ease of use within other technological innovations was seen to positively influence perceived usefulness. Also, it could possibly improve understanding the system because others would be able to deliver personal support or provide lessons learned in practice. Both observations improved participants' self-confidence in ability to use the service, indicating a relation between Social Influence and Expected Effort.

Furthermore, respondents covered the importance of proven benefits instead of speculations. Personal opinions were formed on possible influences of satellite data systems utilizations, but occasionally were not convinced. The **lack of demonstrated and proven usefulness by other users** led to uncertainty within the respondent group. It was deemed expectations could be made based on other farmers who might successfully use the innovation. Since respondents stated waiting with system adoption until others were convinced by it's capabilities, could mean that currently non-users were lacking understandability of the systems benefits and use practices. In other words, this suggests that Social Influence contributes to Expected Performance through Expected Effort. This bottle neck in understanding might be influenced by increase in support and infrastructure, Facilitating Conditions.

5.3.2 Contextual moderator influences

Certain conditions and characteristics were observed strengthening or weakening above mentioned interactions of Social Influence with other variables. Age differences between respondents could state observed differences on influence by social connections. Older respondents were more certain of their current cultivating methods without use of satellite data systems than younger respondents. Younger respondents were often more recently educated and thereby more in direct social contact with other potential users. (Prior) knowledge and experience of others' use of different systems also seemed to contribute to perception of satellite data systems. Even though the technology was different, experience of others adoption and utilization of other technological systems deemed to positively influence contribution of Social Influence on other variables.

5.3.3 Intermediate reflection and recommendation

Even though a possible relation of Social Influence on Expected Performance through Expected Effort was noticed, validation is still obligatory to make grounded claims. The group of participants did not know users of the satellite data systems, thus the relation was made through Social Influence of other technology experiences like GPS-system use.

Through **further quantitative research** the possible relation can be validated. In addition, **future qualitative research** on moderator variables influencing perceived usefulness can broaden the picture of contextual, characteristics and conditions in play influencing strength within the stated relation chain.

5.4 Facilitating Conditions

5.4.1 Facilitating Conditions influence on Expected Performance through Expected Effort

Since respondents stated complications with ease of use, recommendations of necessary improvement were made. It was stated that lack of supporting systems, refrained users from easy application of the technology. Therefore suggesting a possible relation between provided support systems and infrastructure leading to not understandable data sets and unreliable data interpretation by the end users.

In addition, the outcome of the experiment underlines the above stated relation. During the experiment in understanding the provided satellite data types, resulting in an increase in understanding. Because of necessity to enhance understanding, *Facilitating Conditions* were deemed important, showing a direct link between Facilitating Conditions and Expected Effort.

Thus, higher ease of use and understanding is expected to be supported by more support and infrastructure. Respondents indicated better support for farmers through new system components might increase understanding and insight, leading to better insight in the systems capabilities and possible benefits. Respondents mentioned further development of satellite data systems contributes to better data understanding and decision making, therefore increasing perceived usefulness. The influence of sufficient Facilitating Conditions on Expected Effort reinforces farmers' perception on Expected Performance. The action of Expected Effort on Expected Performance was also mentioned in the previous subchapter thereby strengthening plausibility.

5.4.2 Contextual moderator influences

Certain characteristics and conditions seemed to strengthen or lessen influence of Facilitating Conditions on other variables as stated above. Respondents Age seemed to influence the need for support. Younger farmers were more keen with understanding of satellite data systems than older farmers, therefore needing less support. Education also lessened the need for support systems because respondents with recent education were observed having more (Prior) knowledge and experience with the system. These moderators seemed to lessen the need of Facilitating Conditions because they influenced current understandability and levels of insight.

5.4.3 Intermediate reflection and recommendations

Even though a possible relation of Facilitating Conditions on Expected Performance through Expected Effort was noticed, validation is still obligatory to make grounded claims. Further **quantitative research** on specific influences of support and infrastructure changes might also show a change in perceived ease of use and usefulness, thereby possibly increasing validation and reliability.

The possible relation can be validated. In addition, **future qualitative research** on moderator variables influencing perceived usefulness can broaden the picture of contextual, characteristics and conditions in play influencing strength within the stated relation chain.

5.5 Price Value

5.5.1 Price Value influenced by Expected Performance through Expected Effort

Respondents mentioned possible benefits by system use like higher amount of crop yield and quality would increase willingness to pay for the system. Through more revenue gained by more proactive farming, the system was deemed to be of value. Respondents were more willing to pay for the system when costs were lower than the returns. Thus by elevating return rates through increased perception on possible revenue, participants were more willing to invest and thus less hesitating over potential costs. These statements made by respondents showed a possible relation between Expected Performance on Price Value.

In previous chapters, perception on ease of use was also linked to a relationship on expected possible benefits and overall usefulness. When respondents reckoned the system was not user friendly or in some cases unusable, the perceived benefits were expected not favorable resulting in costs being perceived as too extensive. Therefore, an influence of Expected Effort on Price Value through Expected Performance was possibly observed. This influence could possibly be backed up through respondents refraining from making grounded and clear statements on costs-return. Respondents often explained they were simply lacking knowledge and understanding of possible system use cases and benefits, with that showing the potential influence chain. But this is still for debate, since the amount of statements backing this up were very limited.

At last, respondents stated direct costs were not the only perceived monetary investments. Some stated ease of use was negatively impacted because of current equipment being not advanced enough for integration with provided data, making use of the system less practical and more time consuming. Therefore, possible benefits were decreased by lack of Facilitating Conditions. Earlier it was stated perceived acceptable costs were influenced by expected revenue. Expected revenue, which can be classified as Expected Performance is influenced by ease of use and therefore indirectly by provided support and infrastructure of the system. In short, Facilitating Conditions could possibly influence Price Value through other variables.

5.5.2 Contextual moderator influences

Certain characteristics and conditions seemed to strengthen or lessen influence of Price Value with other variables as stated above. Differences between respondents based on agricultural firm type were observed. Arable farmers expected higher benefits than biological farmers, since they could anticipate more on provided data. In addition bigger size farms with higher crop amounts and diversity were also deemed perceiving higher levels of Price Value. This might influence the relation of Expected Performance on Price Value, increasing perceived cost-return ratios positively.

5.5.3 Intermediate reflection and recommendations

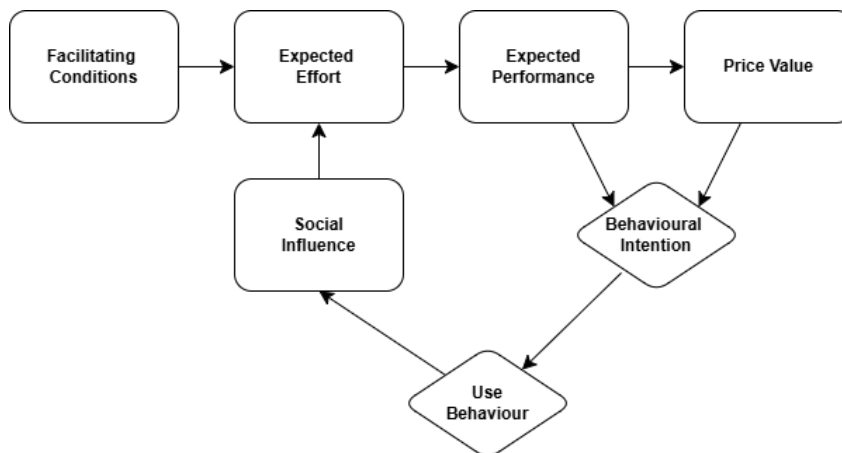
Strength of Price Value relations with other variables relations is deemed less proven than other interactions of other variables. Respondents often lacked knowledge of system pricing, therefore weakening suggested relations. Therefore it is recommended to perform further **qualitative research** into Price Value to broaden the picture of influences with other variables. In addition, deeper understanding of moderator variables' influence on Price Value could also be achieved through further qualitative research. All by all, founding a better base for further **quantitative research** to validate and increase reliability of proposed findings and interpretations.

5.6 Overall summary of interactions and influence on behaviour

The research showed farmers' willingness to adopt satellite data systems is correlated with many variables. All but one respondent stated not expecting to use the technology within the next few years. Even though current respondents willingness is deemed to be insufficient for current desire to adopt, respondents gave broad insight into factors contributing to influences of other variables influencing variable *Behavioural Intention*. Since Behavioural Intention was deemed insufficient for willingness of adoption, Usage Behaviour is noticed to be not present.

Within previous subchapters within the discussion relations between variables were suggested. All of them were combined in the diagram underneath, used for explanation why the system is not in use and why the respondents were not intending in using it preliminary. First the diagram will be used for explanation of current state respondents refraining from use, then suggestions for policymakers will be made to solve current issues within adoption of the system.

5.6.1 Current state of adoption



Respondents deemed expected usefulness, *Expected Performance*, essential for willingness to use satellite data systems. Most respondents expressed possible benefits by system utilization, but were often not convinced enough to be willing to adopt the system.

Trustability issues and lack of usability (*Expected Effort*) led to decreased perceived practicality and potential benefits (*Expected Performance*) withholding them from willingness to adopt the technology (*Behavioural Intention*).

Since usability was not sufficient for applicable utilization, the respondents stated the addition of support services (*Facilitating Conditions*) was necessary for usability. There was a lack in necessary support and infrastructure, resulting in a level of usability too low for usefulness (*Expected Performance*). Thereby resulting in the system being unsupported enough for intention of use (*Behavioural Intention*).

Direct and indirect costs of the system were currently perceived as too expensive for a sufficient cost-return ratio because monetary returns of system use were deemed too low (*Price Value*). Thereby contributing to a lower level of willingness to adopt the system, influencing *Behavioural Intention* again negatively.

Lack of social contact with users of the system (*Social Influence*) also resulted in less perceived usability, since the respondents did not perceive others utilizing the system, (*Usage Behaviour*). Lowered perceived usability (*Expected Effort*) resulted in respondents being hesitant on usefulness or not being able to predict possible benefits (*Expected Performance*), thereby influencing willingness of system adoption again (*Behavioural Intention*).

Thus, the current state of perceived uncertain benefits, lack of practicality, limitations to support and infrastructure and weak social influences resulted in a system which respondents deemed too uncertain, impractical or costly to adopt at current state. Thereby willingness to use is beneath levels needed for incentive to use. In other words:

Within the respondents group and given the current state of satellite data systems, Behavioural Intention does not reach the level required for Usage Behaviour to occur.

5.6.2 Suggested policy framework

Based on the current adoption situation of the respondents, the following policy framework is suggested to increase incentive for possible satellite data systems adoption by current non-users:

Through addition of support and infrastructure (*Facilitating Conditions*), usability of the technology (*Expected Effort*) could be increased. By an increase in usability, it is expected to possibly result in more perceived usefulness and expected benefits (*Expected Performance*).

The improvement of perceived usefulness and expected benefits (*Expected Performance*) will result in an increase of better monetary returns, increasing the cost-return ratio resulting (*Price Value*). Better *Price Value* in combination with enhanced *Expected Performance*, will possibly increase willingness of use (*Behavioural Intention*) to levels enough for non-users to be nudged in adopting the satellite data systems (*Usage Behaviour*). These new users will then, through social contact with other non-users (*Social Influence*), increase perceived usability of non-users (*Expected Effort*). Thereby resulting in a reinforcing feedback loop, ultimately nudging more and more non-users into using the technology.

Thus, addition of more support and infrastructure could result in farmers perceiving the system as more usable, practical and cost-return ratio in proportion. This might lead to more willingness to adopt and thereby resulting in farmers being more likely to start using the system. In other words:

It is suggested that improvement of Facilitating Conditions might lead to more Behavioural Intention, by strengthening the incentive to adoption thereby leading to improved Usage Behaviour.

5.7 Overall research reflection and recommendations

5.7.1 Research reflection

Within researched relations between UTAUT-variables including UTAUT2's Price Value a varying degree of empirical grounded observations were made. Although multiple relations were interpreted based on research results, these were not proven causal and therefore suggestive. Relation chains of more than three variables are deemed more suggestive than others and therefore deem further backing through future research.

The original research model suggested variables most importantly influencing willingness to use on a more individual basis. During the interviews and experiment these variables appeared to influence another more than expected in the theoretical UTAUT model. This insight led to changes in research approach by introducing abductive elements. Original theoretical variables and their definitions were retained, although relations between these variables were abductively interpreted based on received data and context. Through flexible approach results were more effectively analysed which contributed to validity of the result within the researched respondent group.

Although UTAUT with inclusion of Price Value contributed to selecting relevant determinants, the quantitative design of the model proved to be less appropriate for qualitative research than expected. As a result, a balance between deductive and abductive research was made in favor of better understanding of contextuality and adoption willingness within the respondent group.

The experiment was perceived as a useful method within this research, contributing to improved understanding of underlying relations. During the experiment, respondents were assisted in interpretation which was deemed to result in a change of perceived usefulness. Being able to observe the respondent's behaviour and answers led to more validation of the proposed influence of respondents' understanding of the system on other variables. It showed respondents' view basis was not fixed and therefore showing opportunity for change through intervention, leading to better expectancies for feature supporting structures able to improve willingness to use and ultimately thus use behaviour.

5.7.2 Final recommendations

Further research recommendations were previously already mentioned in subchapters within the discussion. Summarizing, it is recommended to take note of the following key areas to increase reliability and validity for further research:

Relations between UTAUT-variables including UTAUT2's Price Value should be causally proven through future quantitative research. Within this research the relations were deemed plausible, but not backed up enough for further generalization. Interpretations were made through pattern recognition within coding layers, which supports plausibility but does not make it explicitly reliable for proposed conclusions outside of the respondent group. Future quantitative research could prove made conclusions and increase reliability for generalization beyond the respondent group. In addition, further quantitative research could provide more insight into overall influence rates of moderator variables. Broader context of

moderator variables contribution to the whole model can also be obtained through further qualitative research.

Even though research results and conclusions can not be generalized to a bigger picture of Dutch farmers, they do provide valuable leads to future research approaches. Observed interactions and contextual factors may be used as contribution to future research questionnaires. Possibly increasing the validity through a broader view on technology adoption, influencing questionnaires for both qualitative as quantitative research.

5.7.3 Positionality

Positionality of the researcher is important to notice. When research started I had a different view on the case than most respondents. As the research proposed, contextual factors are also expected to influence perception. Thereby I am no exception. Positioned outside of the agricultural environments with no social contact to farmers in addition with an academic background in GIS-systems and Remote Sensing, I had a different view on adoption and utilization benefits of satellite data systems than most respondents. My different view on the research case resulted in more critical reflection on respondents' opinions, but potentially leading to bias.

Nevertheless, through contact with respondents I noticed an increase in understanding of agricultural complexity, my opinion being more nuanced by the social influence of the respondents. During the research I became more noticeable of possible perceived biases resulting in more neutrality. Personally the research underlined the importance of noticing different sides of a story, resulting in a more neutral overview over use benefits.

6. Conclusion

This bachelor thesis research investigated adoption and utilization of satellite technology of Dutch farmers in the northern Gelderland Region. This chapter concludes the research and answers the main research question:

Main-RQ: *Which factors influence the current adoption and utilization of satellite data systems for Dutch farmers in the northern Gelderland region, and what factors influence successful implementation?*

To answer the main research questions, three sub research questions were compiled. To answer the main research questions, the sub research questions will be answered first. Then these findings will be used to answer the main research question. At last, implications and recommendations shall be discussed.

Sub-RQ1: *To which extent do Dutch farmers in the northern Gelderland region currently adopt and utilize satellite data systems?*

Results cover actual use of satellite data systems by Dutch farmers from the northern Gelderland region is currently limited. Only one of the interviewed respondents stated they used a system with tangents to satellite data systems. The majority of respondents were convinced of possible usefulness, but were not planning on adopting the system in the coming years. The technology was deemed not developed enough to be currently practical. Therefore limiting its perceived possible benefits. Satellite data systems were currently in an early development phase in which usability, accessibility and reliability were not meeting demands.

The current state of the technology was perceived lacking integration with farmer's machinery, was sometimes found too obscure to anticipate with and was missing support features and infrastructure. There was interest in the systems and their capabilities, but respondents still refrained from actual use. This meant use of satellite data systems by the research group was not present.

Sub-RQ2: *Does perception based on prior based knowledge influence farmers intention to adopt and utilize satellite-technology in agriculture?*

Interviews showed perception playing a key role as an intermediating factor between other variables contributing all together to adoption willingness. Respondents based their attitude on personal experience, absence of social influence or insufficient knowledge. There was hesitation on possible capabilities of satellite data systems, partly due to lack of insight in tangible applications and benefits.

Additionally, interviewed farmers perceived systems in their current state as too difficult, partly due to lack of supporting systems and infrastructure like advanced machinery and advisory services. These factors together influence willingness to adopt the technology.

A low expectancy of usability together with doubt on current possible benefits and limited social influence, resulted in farmers having insufficient incentive to effectively influence them into adopting the service. In some cases it led to low respondents rejecting the systems.

Thus, perception based on limited ability of understanding led to insufficient perceived benefits, therefore lowering willingness to adopt.

Sub-RQ3: *Through which measurements can Dutch farmers in the northern Gelderland region be supported in adopting and utilizing satellite data systems?*

Different respondents made suggestions for improvement of satellite data systems. The need for support was the most recurring theme for improvement, both in technical development as well as guidance for data interpretation and decision making. These needs for further addition of supporting services and infrastructure played a key role, they did not only influence perceived usability, but also the systems expected usefulness.

Through reduction of visualization complexity, addition of expert-based advice and self-learning data systems for decision making, perceived difficulty of use can be remedied. Expert contribution for better decision making was only desirable when there was an open dialogue between farmer and expert. For best expected results of system based anticipation, decision making should be based on farmer's knowledge of their land and the advisor's expertise on satellite data. Interplay between both would deliver most efficient decision making and preserve farmers autonomy. With increased usability, expected benefits increase by better understanding of the system's capabilities resulting in more willingness to adopt and utilize the system.

Some respondents stated the importance of proportional price-return ratios. By more transparency and additional various priced services for different farmers' needs, price-return ratios can be increased. This is deemed to further increase willingness of use.

At last, increased willingness of use leading to actual use of the system would result in a possible snowball effect. Adoption and utilization by farmers might lead to an increase of social influence on non-users. Therefore increasing perceived usability and usefulness again, resulting in more and more non-users willing to try satellite data systems in the future. Thus, through addition of facilitating conditions, non-users can be nudged into use since social influence within networks is present. Thereby underlining the importance of further development of satellite data systems.

Taking in account the answered sub research questions, the main research question can be answered as follows:

Main-RQ: *Which factors influence the current adoption and utilization of satellite data systems for Dutch farmers in the northern Gelderland region, and what factors influence successful adoption?*

Based on the results and analysis it can be concluded current adoption of satellite data systems is limited. Factors contributing to non present Usage Behaviour are:

1. Low Expected Performance: Farmers are hesitant on current practicality and usefulness since the current state of systems do not provide proven and tangible benefits.
2. High Expected Effort: The system is being perceived as too complicated for use, therefore limiting farmers' perceived possible benefits.
3. Lack of Facilitating Conditions: Support and infrastructure is currently insufficient for practical use. This results in more perceived difficulty of use and less insight in systems capabilities.
4. Negative Price Value: Costs outweigh returns. Direct costs were not deemed out of proportion with possible returns, but indirect costs limited willingness to use negatively.
5. Weak Social Influence: There were no current examples of other system users influencing the other non-users through sharing usage experiences. Social constructs for social influence were present, but the technology was yet to be used within them.

Mutual influence of these adoption factors led to low Behavioural Intention, deemed too low for presence of Usage Behaviour. To solve current absence of Usage Behaviour, improvement and further development of the systems are needed through:

1. reduction of complexity through limiting information intake;
2. addition support and infrastructure systems for decision making as a result of interplay between farmers and satellite-data-experts;
3. implementation of self-learning systems;
4. integration with other systems;
5. more transparency and diversely priced service levels with different costs-return ratios.

It should be noted legislation also played a role in perceived usefulness. Legislation affected perceived anticipation capabilities in certain situations, resulting in lowering of willingness to use because of uncertainty as a result of external factors.

Only when the adoption factors are improved through implementation of above stated conditions, Behavioural Intention is believed to increase, ultimately resulting in more Usage Behaviour. This way, through reinforcement of social influential structures, it is believed the technology can find broad adoption and utilization by Dutch farmers in northern Gelderland.

It is also important to highlight the role of presence of complex moderator variables influencing respondents perception on the technology. These contextual factors were different per respondent and therefore making relations more complex. Age and farm conditions were deemed most important conditions and characteristics having an influence on observed relations between variables.

This research was performed qualitatively, therefore focussed on context and interpretation of variable relations. While the conceptual model was based on quantitative models and input variables were not directly linked to another, the purpose was to understand complexity and interplay between variables to gain insight in their influences. Initially the research was meant to be performed deductively, nevertheless interpretation of results were performed abductively. Thereby causality between variables was not proven, but based on interpretative insight

Due to limited sample size, reliability of proposed findings cannot be generalized. Though, proposed insights base a foundation for future research including focussed on increasing reliability and proving causal relations suggested. By usage of concluded research results, quantitative questionnaires could be improved in combination with bigger sample sizes increasing future research validity and reliability.

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