Prioritisation of Factors that Influence the Digital Platform Selection in Agriculture

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Abstract - **In our previous research, we identified a list of factors that influence the digital platform selection by producers of agricultural products and a list of factors that influence customers' digital platform selection. The next question that becomes a focus of our interest is related to the prioritization of those factors. The first results suggest that some factors have a higher impact on producers (or customers) than others when deciding on digital platform selection in agriculture. In this paper, we will present several approaches that can be used to prioritize factors. Those methods are: direct assessment method, reciprocal ranks, SWING, pairwise comparison, analytical hierarchy process, analytical network process, and SNAP method. Some of those methods are simpler, and some are complex. In general, simpler methods are less, and the complex methods are more precise in terms of prioritization. On the other side, simpler methods are more understandable to the average customers (or producers) in terms of application than the complex methods. We analyzed all prioritizations methods and suggested the most appropriate method having a mind on the complexity of the method (understanding by users) and their precisions.**

Keywords – agriculture, digital platform, prioritization

I. Introduction

Platform-based businesses are getting more and more significant as competitors due to their gaining of market share in relation to customers and scope. Due to various disruptions in the environment, digital platforms' introduction is planned and performed to respond to changing demands and preferences in digital-oriented environments. In that sense platforms are important creators of business ecosystems. They gather various market participants and can support coordination and transaction based ecosystems. Therefore, digital platforms are important part of overall digitalization process that is transforming farms and agriculture of 21st century. Simplified, two actors who meet on a platform to trade and exchange goods are the seller (producer) and the buyer (customer). Perceived value and risk are two significant factors for their intention to join or their intention to adopt a digital platform [1]. The Perceived Value may differ from Value Proposition initially designed. A value proposition can be derived from traditional methods for a generic customer or can be formed by applying design thinking methods and techniques (like Personas, Customer journey mapping) ideated for specific customer types.

Most importantly, a Value proposition is a statement of what the customer should be gaining by using the platform. It is not limited to the objective measures set during the design phase of a platform but must refer to the perception of what the product or service is worth in relation to a problem that the customer wants to solve. Trust is a reasonably complex but crucial element of perceived value in the case of a digital platform. Some authors explore the distinction between personal and system trust, whereby personal trust is more associated with community-based platforms, and system trust is related to technology-enhanced mass trade channels (like Airbnb) [2]. The study advocates that "trust, coherency, and cohesion are higher in the community model" and that the system trust is as good as the promised value proposition is delivered or as good as it fits the reality behind the promoted expectations. On the other side, the risk is dealing with trust incidents and issues, leading to different approaches in providing reactive mechanisms for protecting buyers and sellers.

Previous research by the authors of this paper resulted in the Conceptual model of initial utility perception factors for digital platforms focusing on agricultural products in rural areas [3] since agriculture showed high exposure to global disruptions with a high need for sustainability. Decision making based on perception factors related to joining or adopting digital platforms in agriculture confirmed it as a complex process. To ease the selection and decision process, we investigated factors that influence the perceived value or perceived risk and thereby impact joining and adopting digital platforms. This research was performed as a continuation of previous investigations on decision making within the scope of the research project, aiming to explore intuitive multi-criteria decision models for platform preference which can be seen as a contribution to academic and professional implications.

Section II of this paper contains the theoretical background of the topic. In section III, different methods that can be used for determining the criteria weights are discussed. Finally, Section IV contains a demonstration of the application of different methods for determining the criteria weights on the case of prioritization of factors that influence the digital platform selection in agriculture.

II. Theoretical Background

In order to test theoretical options for supporting the decision making on preferences in implementing digital platforms in agriculture, we relied on a conceptual model of initial utility perception factors previously designed within the same research project [3]. The conceptual model of initial utility perception factors proved to be sufficiently complex and feasible enough to perform additional testing in order to design a solid decision making model. The model describes ten perception factors for each of two actors (consumers and producers) which influence their intention to join or adopt a digital platform. The approach of focusing on perception factors was chosen in order to distinguish this research from other approaches, which are more oriented on technological issues [4]. This approach is based on the assumption that technological factors play an important role in the decision making process when potential users show a certain maturity in using similar platforms or are competent enough to distinguish platforms on technology-related properties. Since the agricultural domain requires other knowledge and competencies rather than technology and is highly value-oriented due to its food and health-related impact, intrinsic perception factors seamed to be worth exploring. For the purpose of enabling a better understanding of the perception factors identifyied in previous research as relevant, questions relevant for deep understanding of potential customers and sellers which can provide more clarity on the each factor and give insights for the design of platform functionalities are listed in Table I.

TABLE I. FACTORS OF PERCEPTION

Factor	Customer or producer related	Questions relevant for the design of platform features
Eco-friendliness	Customer	Is eco-friendliness something a typical customer cares about? To which phase of the product lifecycle does this relate to (production, packaging, delivery)? How does this affect the safety concerns of the customer?
Location & time (from farm to fork)	Customer	What is more important to the customer: the location the time? Does a typical customer care about location and time for each phase of the product lifecycle?
Relationship history with the producer	Customer	How does the reputation of the producer impact customer's willingness to trade? How do incidents with the producer affect the overall opinion of a single buyer? Are these experiences something a typical customer is likely to share with others? Does the platform give incentives to share anything?
Payment options	Customer	How is the price of the products outlined? Is it possible to keep track of price volatility? How do customers feel or think about payment security? How accessible is information on costs or discounts?
Comfort & convenience	Customer	What new value does the platform provide? Which feature would be a deal-breaker for the customer to decide to join a Platform? What would make a customer's experience more useful or convenient? What does the customer gain more in relation to competitive or alternative solutions? During onboarding, are there any obstacles? Is there a feature that would provide a sense of a reward or specific enjoyment? Which benefits like time-saving and reliability of delivery would the customer prefer?
Recommendations (C2C2C)	Customer	If a customer expects a community-based model, which features of community experience would be expected? Which reward-related options are available in terms of a recommendation system? Would customers prefer a "call to action" near the recommendation feature?
Community support	Customer	Does it support the sustainability and development of the local economy? Is local production something the community is dedicated to? How relevant is the sense of reward social responsibility?
Producer's reliability	Customer	Would customers prefer an overview of the producer's value chain in whole or a detailed view of the chain-like product's specific elements inbound logistics, delivery, operations, and sales? How is producer's reliability correlating to the recommendation subsystem? Does reliability correlate to comfort and convenience experience?
Trust & traceability	Customer	How would customers prefer or rate features for building trust among the platform community? Is traceability a trust-related must-have, or is it a property that needs to be based on objective data? In terms of white pollution by to-much-information, is it preferred to enable traceability through the whole value chain, including preparation, production, harvesting, and delivery?
Health & safety	Customer	During disruption challenges like pandemics, does the platform respond adequately to health-related awareness building? Which food safety features are expected? How important are health and safety features in the sense of evaluating the quality of life and satisfaction?
Sales channels	Producer	Which sales channels are preferred by customers and which by producers? Which touchpoints in the sales process are contributing to loyalty? Does the trade through specific channels increase the workload on the producer side? Which barriers impact the entrance on markets, and are these barriers related to technology or organizational factors?.
Health & food safety	Producer	Does the platform provide enough space for distinctive health and food safety population? Are there any incentives for providing additional services above average related to food safety? How are incidents handled, and which risk prevention options are in place? Does the platform provide traceability in case a producer is oriented on specific niches?
Production technologies	Producer	Does the platform provide features for communicating "Green deal" or data on the carbon footprint? Are interfaces available for remote production overseeing at the producer or customer side? Is it expected to relate production technologies with product quality functionalities?
Product Quality	Producer	Does the platform enable features to communicate product information in the appropriate form and by enough product description options? How easy is it for maintaining appropriate information on products or services?
Resources	Producer	Which issues would the producers want to be handled by the platform besides sales? Which gains can be achieved by the endorsement of digital technologies in empowering and supporting human labor? Which interfaces to advanced subsystems, including AI, robotics, precision agriculture, and other innovations, are available? Which competencies are necessary to profit from the platform adoption?
Inbound logistics / Supply Chain	Producer	Does the platform include other inbound logistic stakeholders of the eco-system? Does the platform provide an open-data strategy in building disruption resilient eco-systems? Does the platform supply options for managing relationships and channels to suppliers of raw materials (seedlings and seeds, fertilizer)? Are features available which could contribute to a more efficient supply chain?
Innovations	Producer	Does the platform need to provide support for innovation processes? Does this benefit the rating of producers? How does the platform facilitate the identification of innovation potentials, design of innovations, or their evaluation?
Outbound logistics / Distribution chain	Producer	Does the platform include other outbound logistic stakeholders of the eco-system? Which features related to handling orders, preparing delivery, packaging, and performing delivery should be available? How and to which extent should intermediate actors be included in collaboration?

Incentives and sustainability	Producer	Besides platform usage rewarding for customers, does the platform provide rewards for producers? Which incentives for adopting the platform would affect producers' readiness to adopt new technologies in their business? Does the platform contribute to more sustainable business models?
Regulatory compliance	Producer	Does the platform facilitate administrative assistance for producers in relation to regulatory compliance? Does the platform support the producers in reaching health and safety-relevant objectives or dealing with issues related to ensuring compliance? Does the facilitation in compliance benefit the producer, which can be translated into better business outcomes?

III. Criteria Weighting Methods

There are many methods in multi-criteria decision-making that can be used in terms of weighting the criteria in the decision-making problems. In our case, the criteria' role is given to factors because the factors are the attributes due to which the final platform selection is performed. It is essential to state that before weighting the criteria, they have to be identified and structured correctly [5]. In the structuring process, many methods can be helpful, and some are discussed in [6]. In our case, the criteria (factors) are already known in the previous research [3], [7].

The criteria methods that are discussed in the scope of this paper are:

- Direct assessment
- SWING method
- Reciprocal ranks method
- Pairwise-comparisons method
- The AHP (analytic hierarchy process)
- The ANP (analytic network process)
- The SNAP

A. Direct assessment

Direct assessment is the simplest method for weighting the criteria. In this method, the decision-maker collocates 100% on all criteria in the decision-making problem. A complete reasoning process is happening in the decision maker's mind respecting his/her experience, desire and intuition. Even though this procedure seems to be very simple, it is not. It is always essential that experts in the field of the decision-making problem implement this procedure. Otherwise, the results can be dangerous for the decision's effects if a non-expert person implements the direct assessment.

B. SWING method

In the SWING method, the procedure is the following. The decision-maker has to select the most important criterion in the model and gives it 100 points. After that, for each other criterion in the model, the decision maker judges how much *of the most important criterion falls on the observed criterion*. After this procedure is finished for all criteria in the model, the criteria weights are calculated by normalization by the sum of all points.

C. Reciprocal ranks method

There are two ways of how to implement this method. In both cases, the first step is to rank all the criteria in the model. The second step is to calculate the reciprocals of the ranks. Then the two procedures differ:

- In the first procedure (RR), the third (and last) step is normalization by the sum of all reciprocal ranks
- In the second procedure (ROC), the third step is to create cumulative series (sequence) respecting the reciprocal ranks. The last step is to divide each member of the cumulative series by the number of criteria in the model.

D. Pairwise-comparisons method and the AHP

When compared to the previous methods, the pairwise-comparisons method is more complex. Here, the Saaty scale is used [8], [9]. It is consists of nine values. Particular value on the scale describes the relationships between two elements. If two elements are equally important, we use one on the Saaty scale. If one element is more dominant than the other, then we use the numbers from 2-9 depending on the level of dominance.

In this method, the procedure is as following [10], [11]:

1. The creation of the square matrix where number of rows/columns equals the number of criteria in the problem. This matrix will be filled with Saaty values respecting criteria that are connected with rows/columns. On the main diagonal, we write values 1 (particular criterion is compared to itself).
2. Comparing criterion from row x with criterion in column y: the decision maker has to give judgment on dominance of one element over another (using value on the Saaty scale). If x dominates over x, the Saaty Value is interted on the position (x, y), otherwise the Saaty value is inserted on the position (y, x). At other position that describes the relation between x and y, the reciprocal value of Saaty value has to be inserted. Here, it is important to take care on respecting the consistency: applying the transitivity concept on the Saaty scale.
3. Normalization of pairwise-comparisons matrix by sum.
4. Powering the normalized matrix until it converges. Then, from columns of the matrix, criteria weights can be identified.
5. It is also possible to calculate the inconsistency ratio, which has to be under 0.1, to conclude that the pairwise-comparisons matrix is consistent.

The AHP is an upgrade of the pairwise-comparisons procedure. Here, the criteria can be decomposed into subcriteria and further at the lower levels. Respecting the axiom of the dependence [12], the same level criteria have to be compared with respect to their superior element from one level above them. The final criteria weights are calculated by multiplying the criteria weights of a higher level of the hierarchy with criteria weights on lower levels until the last level. Creating the hierarchical structure of the criteria is welcome because it decreases the complexity of giving input judgments when compared to the linear presentation of the criteria.

E. The ANP and SNAP

The previously mentioned methods can be applied in the situation where the criteria are not mutually independent. However, in most cases, in the decision-making problem, we have dependent criteria, and that information has to be included in the procedure of calculating the criteria weights. Here, the ANP can be used. The ANP, as AHP, uses the pairwise-comparisons procedure as the primary mechanism for determining the criteria weights. In ANP, the criteria are grouped into clusters of criteria.

The procedure is as follows [13], [14]:

1. Creating the zero-one matrix of the influences between the criteria and creating the matrix of influences between the clusters of criteria,
2. Creating the unweighted supermatrix: The matrix of influences between the criteria is being transformed into an unweighted supermatrix in which the values "1" are replaced with local priorities. The priorities are calculated by making pairwise comparisons of criteria from the same cluster that influence the same criterion from their and/or different clusters,
3. Creation of matrix of weights of clusters by pairwise-comparisons of clusters with respect to the cluster they influence,
4. Creation of the weighted supermatrix that is calculated combining the unweighted supermatrix with the matrix of the weights of clusters,
5. Calculating the limit supermatrix by multiplying the weighted supermatrix with itself until it converges.

If the criteria are weekly connected, the weights of some (or all) criteria may be zero on end [15]. This is why the ANP is not recommended for calculating the criteria weights "alone" without including the model's alternatives in the same procedure. The ANP is characterized by the inseparability of the criteria and alternatives [16]. However, if we still need only criteria weights, and the alternatives are not known, the procedure including the fictive alternative can be implemented, resulting in the correct calculation of the criteria weights [17].

Besides, in ANP, only dependencies between the criteria influence the final weights when calculating the criteria weights. The criteria strength with respect to the goal does not have any influence on the final priorities. This is why the SNAP method has been created. By using SNAP, we can combine both dimensions of the criteria weight: (1) the strength of the criterion (like in all previous methods), (2) the intensity of affecting other elements [18]. The steps of the SNAP are as follows [19]:

1. Creating the matrix of priorities of elements respecting the relations between the elements (C).
2. Calculation of the normalized matrix of elements' priorities (S) (starting matrix is divided by the highest column sum)
3. Calculate G=0.85S+0.15E (the dimension of E is n, and each value of the matrix is 1/n).
4. Calculate G(I-G)-1.
5. Calculate the centrality indegree and outdegree and their difference (r).
6. Calculate the maximal difference between any r, and add it to r.
7. Normalization by sum.
8. Agregating the previous step with results of AHP (or another method that determines the criteria strengths).

IV. Application of Criteria Weights Methods on Prioritization of Factors that Influence the Digital Platform Selection in Agriculture: Demonstration

In this part of the paper, we will demonstrate how each of the previously mentioned methods can be applied for the prioritization of factors that influence the digital platform selection in agriculture.

The applications of the directed assessment method, is demonstrated in Table II.

TABLE II. FACTORS' WEIGHTS USING THE DIRECT ASSESSMENT

Factor (Customers)	Criteria weight	Factor (Produces)	Criteria Weight
Eco-friendliness	0,05	Sales channels	0,1
Location & time (from farm to fork)	0,1	Health & food safety	0,1
Relationship history with the producer	0,1	Production technologies	0,05
Payment options	0,2	Product Quality	0,2
Comfort & convenience	0,1	Resources	0,05
Recommendations (C2C2C)	0,1	Inbound logistics / Supply Chain	0,15
Community support	0,05	Innovations	0,05
Producer's reliability	0,1	Outbound logistics / Distribution chain	0,15
Trust & traceability	0,05	Incentives and sustainability	0,05
Health & safety	0,15	Regulatory compliance	0,1

In Table III we can see the weights of the factors of perception using the SWING method.

TABLE III. FACTORS OF PERCEPTION – SWING METHOD

Factor	Points	Weight	Factor	Points	Weight
Payment options	100	0,18	Product Quality	100	0,15
Health & safety	80	0,14	Inbound logistics / Supply Chain	90	0,13
Relationship history with the producer	80	0,14	Outbound logistics / Distribution chain	90	0,13
Recommendations (C2C2C)	60	0,11	Health & food safety	80	0,12

Comfort & convenience	60	0,11	Sales channels	70	0,10
Location & time (from farm to fork)	50	0,09	Regulatory compliance	60	0,09
Producer's reliability	50	0,09	Innovations	60	0,09
Trust & traceability	30	0,05	Production technologies	50	0,07
Eco-friendliness	30	0,05	Incentives and sustainability	40	0,06
Community support	30	0,05	Resources	40	0,06

Table IV. contains applications of ranking methods for both perspectives. Due to methods' steps, priorities for both perspectives are the same in a specific method.

TABLE IV. FACTORS OF PERCEPTION – RANKING METHODS

Rank	Factor (Customer)	Factor (Producer)	Rec. Rank	M1	CS	M2
1	Payment options	Product Quality	1,00	0,34	2,93	0,29
2	Health & safety	Inbound logistics / Supply Chain	0,50	0,17	1,93	0,19
3	Relationship history with the producer	Outbound logistics / Distribution chain	0,33	0,11	1,43	0,14
4	Recommendations (C2C2C)	Health & food safety	0,25	0,09	1,10	0,11
5	Comfort & convenience	Sales channels	0,20	0,07	0,85	0,08
6	Location & time (from farm to fork)	Regulatory compliance	0,17	0,06	0,65	0,06
7	Producer's reliability	Innovations	0,14	0,05	0,48	0,05
8	Trust & traceability	Production technologies	0,13	0,04	0,34	0,03
9	Eco-friendliness	Incentives and sustainability	0,11	0,04	0,21	0,02
10	Community support	Resources	0,10	0,03	0,10	0,01

The presentation of pairwise comparisons method implementation is given in Table V.

TABLE V. FACTORS OF PERCEPTION – PAIRWISE COMPARISONS

	PO	HS	RH	R	CC	LT	PR	TT	EF	CS	Criteria weights
PO	1,00	1,50	2,00	2,50	3,00	3,50	4,00	4,50	5,00	6,00	0,23
HS	0,67	1,00	1,50	2,00	2,50	3,00	3,50	4,00	4,50	5,00	0,18
RH	0,50	0,67	1,00	1,50	2,00	2,50	3,00	3,50	4,00	4,50	0,15
R	0,40	0,50	0,67	1,00	1,50	2,00	2,50	3,00	3,50	4,00	0,12
CC	0,33	0,40	0,50	0,67	1,00	1,50	2,00	2,50	3,00	3,50	0,09
LT	0,29	0,33	0,40	0,50	0,67	1,00	1,50	2,00	2,50	3,00	0,07
PR	0,25	0,29	0,33	0,40	0,50	0,67	1,00	1,50	2,00	2,50	0,06
TT	0,22	0,25	0,29	0,33	0,40	0,50	0,67	1,00	1,50	2,00	0,04
EF	0,20	0,22	0,25	0,29	0,33	0,40	0,50	0,67	1,00	1,50	0,03
CS	0,17	0,20	0,22	0,25	0,29	0,33	0,40	0,50	0,67	1,00	0,03

In AHP, ten factors are grouped into three criteria (Figure 1). The criteria weights would be calculated in several steps: (1) comparing groups of criteria with respect to decision-making goal; (2) comparing factor from each group with respect to the group – 3 pairwise comparisons procedures; and (3) multiplying the group weights and weights of factors in groups to obtain the final factors' weights. The AHP priorities are presented in Table VI.

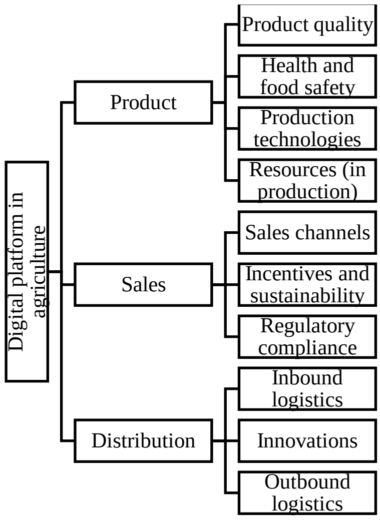

Figure 1. The hierarchical tree (for AHP method)

TABLE VI. FACTORS OF PERCEPTION – AHP METHOD

Goal	Groups	Factors	Local weights	Final weights
Decision-making goal	Producr =0,33	Product Quality	0,50	0,17
		Health & safety	0,25	0,08
		Production technologies	0,13	0,04
		Resources	0,13	0,04
	Sales =0,33	Sales channels	0,40	0,13
		Incentives and sustainbility	0,20	0,07
		Regulatory compliance	0,40	0,13
	Distribu rion =0,33	Inpunt logistics	0,43	0,14
		Innovation	0,14	0,05
		Outbound logistics	0,43	0,14

Due to the limitation of the paper size, the ANP network is not presented, and their steps are not presented step by step. Similarly, SNAP method steps are also not presented. In both cases, the usual method steps are followed to obtain the priorities. Also, here we talk to demo examples – the data that were not collected from actual participants. The role of this research is to select the most appropriate method for determining the criteria weights for factors that influence the digital platform selection in agriculture.

In Table VII, the priorities obtained by ANP and SNAP methods are presented. Priorities obtained by AHP present each factor's strength, and the priorities obtained by ANP present the intensity of affecting each factor on other factors in the systems. Some factors can be very strong in influencing the digital platform selection, but at the same time, without any effect (influence) on other factors (it is independent). Some other factors can be weaker, but at the same time very effective on other factors. The method that combines both dimensions of the criteria weights is SNAP, and we can find its' weights the most aggregative.

TABLE VII. FACTORS OF PERCEPTION – ANP AND SNAP METHODS

Factors	AHP	ANP	SNAP
Product Quality	0,17	0,15	0,16
Health & safety	0,08	0,08	0,08
Production technologies	0,04	0,12	0,08
Resources	0,04	0,06	0,05

Sales channels	0,13	0,09	0,11
Incentives and sustainbility	0,07	0,10	0,08
Regulatory compliance	0,13	0,10	0,12
Inpunt logistics	0,14	0,09	0,12
Innovation	0,05	0,12	0,08
Outbound logistics	0,14	0,09	0,12

The comparison of the methods is given in Table VIII. None of the methods is dominant over all other methods.

TABLE VIII. METHODS COMPARISON

	Strength	**Affecting**	**Precision of the method**	**Complexity**	**Understanding**	**Duration**
Direct assessment	+	-	low	medium	high	low
SWING	+	-	low	low	high	very low
Reciprocal ranks	+	-	low	medium	high	low
Pairwise comparisons	+	-	high	high	medium-high	medium
AHP	+	-	high	high	medium-high	medium
ANP	-	+	high	very high	low	high
SNAP	+	+	high	high	medium-high	medium

V. CONCLUSION

This paper deals with presenting and comparing different methods for prioritizing factors that influence the digital platform selection in agriculture. Perception factors are put in context by defining questions relevant for a deep understanding of potential customers and producers' expectations to gather inputs designing platform functionalities. Further, analysis of prioritization methods based on the methods' complexity and their precision was performed. This analysis allows testing the appropriateness of intuitive multi-criteria decision models for platform preference and is also crucial for the platform design phase. In the final analysis, the analysis showed that the more complex methods are also more precise. If we decide to limit the preference models only to exact methods, we have to decide between pairwise comparisons, AHP, ANP, or SNAP. Using AHP over pairwise comparisons is a much better solution if we have a higher number of factors. In our case, the number of pairwise comparisons that are needed in the pairwise comparisons method is 45, while in AHP, it is 15. Using the ANP, we would not recommend it since it does not cover the strength of the analysis criteria, and there is a poor understanding of its steps. Finally, if we want to include affecting other criteria, the SNAP would be highly recommended.

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