Digital user-industry interactions and Industry 4.0 services to improve customers’ experience and satisfaction in the European bakery sector

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Abstract— Future Industry 4.0 is focused on improving production processes through the employment of digital services and technologies. One of the potential approaches to this new paradigm is the creation of information flows across the entire value chain to empower users, increase their knowledge about the product they are buying and feedback producers with data about the customers’ opinions, preferences, and recommendations. To allow a transparent path for information in the value chain, new digital platforms and tools are needed to connect users, producers, and suppliers. DEMETER is a European project focused on improving the efficiency of agri-food sector, according to Industry 4.0 principles. In this paper, we are describing the use case of DEMETER project focused on bakery industry. Five different experiments focused on sharing four different information sources, together with the corresponding tools to guarantee the reliability and transparency of that information, are planned. Recently, results from the first experiment have been obtained and are reported in this paper. Results show how users’ satisfaction highly increases when enriched and personalized production information about products is available through, for example, mobile applications. In the future, this mechanism will include more information from suppliers and other related agents to analyze if this also represents a relevant increase in the users’ satisfaction.

Digital services; Industry 4.0; Users’ satisfaction; DEMETER; Bakery industry; mobile applications

I. INTRODUCTION

Industry 4.0 [1] is a new paradigm for the future productive sector, where new solutions such as Cyber-Physical Systems [2] and personalized digital services are extensively employed to improve the global efficiency and social utility of production processes. Although, typically, Industry 4.0 proposals are focused on heavy industries in the secondary sector (iron industry, car production, etc.) [3], this revolution must reach every economical sector, including all companies in the primary and tertiary sectors. In particular, one of the key sectors in the global economy is the agri-food sector [4]. Agri-food companies and production processes are currently essential and, in the future and because of the great population growth, this challenging situation will only turn more pressing. Agri-food companies need to become more sustainable, agile, and climate-friendly [5]. At the same time, costumers are each time more demanding about the industry behavior, and they require clear, transparent and trustworthy information about the production processes and the products they buy [6]. In fact, European customers are very aware about the critical situation of agri-food sector, and they demand products with high quality standard, and proofs about how these standards are met.

The strategy to implant Industry 4.0 technologies in the agri-food sectors cannot be homogenous for all companies, and two main subsectors may be distinguished: farming (including precision farming, fruits and vegetables and arable crops) and cattle raising or livestock [7]. Among these two subsectors, in Europe, agriculture is probable the most relevant economic activity, considering its weight in the continental GDP (Gross domestic product).

Actually, agriculture is a major component of Europe’s economy, and the diversity of challenges it faces is addressed by a set of European policies. In addition to Europe’s common agricultural policy (CAP), policies address a whole range of issues, from food (FOOD2030) to bioeconomy (BioEconomy strategy, jointly updated in 2018 by DG Research and Innovation, DG Agriculture and Rural Development, DG Environment, DG Maritime Affairs, and DG Industry and Entrepreneurship). With no common European data space existing for the agricultural sector (and related sectors, such as the bakery industry) and ever more data relevant to farmers and processed products manufacturers being generated by sensors and other devices, farm equipment, production systems and reporting mechanisms, industry players have seized the opportunity to build their own proprietary data spaces that are not interoperable. This forces European consumers to relate to a multitude of different systems, data models and user interfaces in order to access data they need to support their increasingly complex decision making. It has also undermined the potential of farmers and food industry as data producers to fully benefit from the economic potential of the data they generate.
DEMETER [8] is a European project focused on addressing this challenging situation. DEMETER’s ambition is to facilitate and speed-up the deployment of interoperable, transparent, and trustworthy data driven solutions, connecting farmers, raw ingredients suppliers, product manufacturers and final users. These data spaces must create bidirectional data flows through the entire value chain, providing customers with the information they demand, so their satisfaction and power increase; and the same time agents across the entire chain may employ the new information to increase the efficiency of their processes such as marketing (thanks to the information directly reported by users) or provision (through new digital and automatic marketplaces).

Many different pilots and use cases are integrated into DEMETER project, related to many different farming scenarios and related production companies. Therefore, in this paper, we are presenting the use case focused on the bakery industry. In this use case, five different experiments are going to be conducted, considering four different information sources to empower users and improve the efficiency of industrial processes. Users’ opinion and recommendations; enriched and personalized legal product information (ingredients, allergens, etc.); data about the resource consumption and ecological footprint of industrial production processes; and data about the suppliers of the bakery companies are transported across the value chain to reach that objective.

In this first paper, we are focusing on the first experiment. In this experiment, two new mobile applications were deployed and tested by users, who learnt about this new technology in two different workshops. In particular, products about CODAN S.A (a bakery company focused on pastries and related products) were under study. Using two different surveys, two different social groups (representing two target groups for CODAN products) were monitored, regarding their satisfaction and quality of experience (QoE) about the CODAN products. A control group and two groups (each one using a different mobile application) were considered. The mobile applications displayed legal information about products (mainly ingredients, allergens, and nutritional data), personalized and enriched with some additional details such as the ecologic impact (if available for the products). This information was maintained in a database, and could not modified dynamically, as processes to determine that information must follow rigid legal requirements.

The rest of the paper is organized as follows: Section II describes the state of the art on Industry 4.0 services for the agri-food sector, and their proved impact. Section III describes the technological tools we employ to provide customer with the products’ information, the DEMETER ecosystem for the bakery sector, as well as some details about the bakery industry to better understand the experiment design. Section IV reports the conducted experiment, including the methods and materials. Section V presents the obtained results, while Section VI concludes the paper.

II. STATE OF THE ART ON INDUSTRY 4.0 AGRI-FOOD SERVICES

Industry 4.0 services for agri-food sector, or agri-food 4.0, has been a popular topic in the last three years. Basically, four different groups of works could be defined in this context.

First, papers describing the challenges and opportunities for agri-food 4.0 may be found [9][10]. In those works, a new and trustworthy value chain is presented as an essential objective, which must be reached through enabling technologies such as the Internet of Things [11] and research challenges as intelligent farming actions. Typically, these research challenges and opportunities are divided into three sets, depending on the target application field: manufacturers [12][13], producers [14] and the global value chain [15].

A second important type of papers is focused on hardware infrastructures for data generation and automatization. This group includes some new hardware technologies to design new sensing devices [16][19][20], S3 (sensing, smart and sustainable) solutions to acquire physical data [17] and architectures [18] where many promising technologies (such as Internet of Things, Artificial Intelligence and Blockchain) are mixed in order to feed data spaces.

The third group of works addresses and describes technology enablers. These enablers are generic software technologies that must support the transport flow of information across the entire value chain and data space. These technical mechanisms include mobile applications [21], Blockchain network to guarantee the information origin [22][23] and protection solutions against cyberattacks [24][25], among other proposals. Nevertheless, all these works only describe the technical characteristics and performance of these tools, and no analysis or experience related to their social or economic impact has been reported. This paper aims to fill this gap, describing new technology enablers (mobile applications), but also a social experiment about their real impact on customers and producers.

Finally, many articles describing mechanisms to manage the supply and value chains in agri-food 4.0 may be found [26]. Solutions based on Big Data [27] integrated into data spaces to make decisions, frameworks supported by process modeling mechanisms such as BPMN [28] and commercial digitalization techniques to reduce the management cost of the supply chain [29] have been investigated. Some initial proofs about the social and economic success of these management solutions are also available, although a more formal and scientific analysis is required to extract solid conclusions. In this paper, this objective is addressed.

III. NEW INDUSTRY 4.0 SERVICES FOR THE EUROPEAN BAKERY SECTOR

In this section, the proposed new digital services to create new user-industry interactions and empower customers, increase their satisfaction, and improve the efficiency of processes in the bakery industry are described. Subsection III.A presents the value chain, target markets and main processes in the bakery industry. Later, Section III.B describes the proposed DEMETER ecosystem for this industry and what elements in the previous value chain and processes are
affected and improved. Finally, in Section III.C, the mobile applications from the DEMETER ecosystem, required to develop the referred first experiment are explained in detail.

A. The bakery value chain, market and processes

Bakery industry may present important differences, depending on the analyzed European country. Therefore, in this subsection we are focusing on the Spanish company CODAN.

CODAN is one of the leading manufacturing in the pastry and bakery Spanish industry. In the last ten years, CODAN has extended its products’ commercialization to several external markets in the European Union, America and Africa. Besides, CODAN has received an International Food Quality and Safety Certification, as a recognition to the quality of its products. Basically, CODAN supports six main product families (see Figure 1):

- **CODAN originals**: This family includes the most traditional pastries, baked by CODAN since 1961. Different formats are included in this category, provided that the product was manufactured since the company foundation.
- **CODAN family**: This line includes all products that are distributed in large formats (such as one-kilogram packages), that are specially thought to be sold in supermarkets and similar shops.
- **CODAN food service**: This family includes all products that are sold in bulk. Users may select their own products and their amount from a large catalogue, including almost every pastry manufactured by CODAN.
- **CODAN restaurants**: In this category, products are designed to be taken as bakery supply by restaurants, bars, cafeterias, etc. In general, products in this category as focused on breakfast and desserts.
- **CODAN vending**: CODAN’s products are also present in vending machines. Special products, typically smaller than the standard version, are sold in this scheme.
- **CODAN 0% sugar**: In the last years, CODAN has proposed a new family of selected products where no sugar is employed. A combination of products of all previous families are modified to create this recent and new proposal.

On the other hand, four basic market targets are defined in the commercialization strategy of CODAN. At this point it is important to consider that CODAN products are authorized to be sold to the general public, provided they inform users about potential allergies in the packaging. The basic targets are:

- **Child segment**: This segment includes kids between three and fourteen years old. In this target, products are usually bought by parents, although kids are the final customer. Flavors such as chocolate and strawberry are usually employed, and products follow an “on the go” design (adequate to eat while walking, for example). Besides, a reduced quantity of oil and fat is also employed.
- **Teenager segment**: This segment is characterized by low-cost products. It includes people from fifteen to twenty -two years old. Products in this family are distributed in vending machines or as food service, where small amounts and low-cost products are available.
- **General public (families)**: This segment includes the general people, that typically buy CODAN products in the supermarket. Families is a very important subtarget within this segment.
- **Healthy segment**: This target is mainly composed by people worried about the composition and ingredients of products, specially about oil, fat, and sugar. The family “0% sugar” is specially designed for this target.

In order to support all these product families and be present in all target markets, CODAN maintains a very solid and coherent value chain (see Figure 2), whose main processes according to the Porter’s analysis are described below.

- **Infrastructure.** It includes three basic processes. (i) Planification. Strategies (such as product strategy, branch strategy or market strategy) are defined in this process. (ii) Management and Finance. Focused on controlling the budget and investments (iii) Legal support. Especially important for exportations, because of the different food legislation in Europe and America.
- **Human resources.** These activities include excellence policies, processes for long-life learning and talent retention mechanisms.
- **Technology support.** Here we find technology provision processes, focused on resource consumption optimization and efficiency increasing.
- **Supply.** Processes to capture the basic ingredients for bakery products and pastries are considered. Mainly, these processes include ingredients such as: sugar, oil and butter, milk powder, salt, wheat and corn flour, eggs, salt, yeast, packaging, and transport.
- **Input logistics.** Basically, it includes the management processes of the warehouse for raw ingredients.
- **Production.** All CODAN bakery products and pastries are manufactured by combining nine basic production processes: mixing, division, shaping, put in the molds,
baking, cooling, final presentation, quality assurance and packing.

- Output logistics. These activities include, mainly, transport and operation supervision processes. Specifically, transport management, production synchronization and product distribution processes are part of these activities.

- Marketing. In this category, all processes focused on capturing the users’ comments and opinion, improving their satisfaction, and communicating the CODAN strategy and products are included.

- Services. In this case, CODAN does not provide any service at this moment, although in DEMETER project user empowerment services will be deployed. Nowadays, however, this value chain is poorly digitalized.

The main management element is some “product sheets” supported by the Microsoft Excel application, which are not even stored according to a coherent catalogue but accumulated in the file system of a local computer. In order to improve this situation, CODAN and DEMETER project have defined seven basic indicators which should be improved through a digitalization process. Namely:

- Transparency: This indicator measures the amount of information that is transferred across the entire value chain to the final users. The number of parameters controlled in the different steps and communicated to the final users is the basic variable.

- Data management cost: This indicator refers the cost of managing all data from previous steps in the value chain and from processes in CODAN to provide users with high quality information. Two basic variables are measured: the number of person.month invested in this task, and the cost of consumed resources (paper sheets, ink, etc.)

- Feedback: This indicator represents the amount of information that is captured by CODAN from the final users about its products. Basically, the main variable representing this indicator is the number of inputs (users sending their comments or opinions to CODAN).

- Feedback cost: This indicator refers the cost capturing the users’ opinion and comments about CODAN products. Two basic variables are measured: the number of person.month invested in this task, and the cost of consumed resources (paper sheets, ink, etc.)

- Users’ satisfaction: This is a direct indicator about how happy users are about the CODAN products, the consumption experience, the provided information, the ecological footprint, etc.

- Reaction time: This is also a direct indicator about how much time CODAN needs to apply changes requested by users through the feedback capture.

- Decision making cost: This indicator refers the cost of making decision about the CODAN products, when different variables must be balanced (for example, the users’ satisfaction and the ecological footprint). Two basic variables are measured: the number or person.month invested in this task, and the cost of consumed resources (paper sheets, ink, etc.).

DEMETER project will improve the industrial efficiency and users’ satisfaction in CODAN through different technological tools and experiments.

### B. DEMETER ecosystem for the bakery sector

In order to create the needed information flows to improve the customers’ satisfaction and industrial processes efficiency, it is necessary to deploy an enabling technological platform. This platform, see Figure 3, includes five basic enablers, managing other four different information sources. The five basic components are:

- **Mobile ecosystem.** Two different mobile applications for users to recover and consume information about the bakery products are deployed. These applications display, mainly, legal information about products (including nutritional information, ingredients, and some labels such as the ecologic label) taken from the Industry 4.0 platform. Besides, these applications may suggest products to users according to their preferences and allow customers to program alarms and to compare products at any time and store their previous decisions. The purpose of these applications is to empower users and increase their satisfaction with bakery products and experience.

- **Blockchain-enabled marketplace.** This tool will communicate suppliers and bakery producers in order to automate the supplying processes and, at the same time, capture relevant information across the entire value chain in order to provide users with those data. Blockchain technology will ensure the trustworthiness of information and will enable a hierarchical and simple recovery process through, for example, web interfaces. In this case, the marketplace will be connected to users through labeled products (using, for example, QR codes), allowing
customer to get all the information stored in the marketplace regarding a certain bakery product.

- **Recommender system.** Some enablers and information sources from this use case, focused on bakery, are also shared by other pilots and use cases. Therefore, an interoperability space is planned, connecting all tools and pilots in the DEMETER project. In this interoperability space, we are deploying the final a third enabler: a recommender system. Using this tool, users (after consuming some products and their associated information) may publish a recommendations and opinions. This recommendation may be directed to other users, but also to the bakery company. This automatic and direct report will increase the efficiency in some industrial processes such as marketing or sales. At the same time, customers are empowered as their decision capacity also goes up. In order to interact with this recommender system, initial mobile applications will include a new section focused on this purpose.

- **Ecological footprint platform.** Current customers and companies each time more aware about the ecological impact of their activities. However, measuring that impact is not easy. Therefore, in our use case we are deploying a sensing platform collecting data about the ecological footprint (mainly about the electricity consumption and the gas emission). This sensing platform communicates through LoRa technology and a publication-subscription broker (based on FIWARE technologies) with an Industry 4.0 platform where data are stored and processed to calculate the final ecological footprint. Those calculation could be later employed by managers to make decisions in an efficient manner.

- **Monitoring dashboard.** In modern production systems, many variables affect the final result, and decision are complex and costly to make. In order to help managers in this process, a monitoring dashboard will be also implemented in this DEMETER pilot. This dashboard will show, for each product, information from all sources: ecological footprint from the sensing platform, supplier information from the marketplace, users’ recommendations from the Industry 4.0 platform and mobile application and legal information taken from the product database. All this information, automatically collected and deployed together, must allow more efficient decisions. Functionalities such as authorization or security will be provided through DEMETER core components specifically designed for this purpose.

On the other hand, the four considered information sources are:

- **Bakery products data base.** A database containing all essential and mandatory legal information about bakery products is deployed in the interoperability space. This database is based on the open dataset OpenFoodFacts. This data base includes all the legal information about products including: a photo, the weight, ingredients, allergens and nutritional information. This legal information is enriched with other additional data such as a nutriscore, additives, and product classification. Before starting the use case, all CODAN products were published in the database, following the collaborative approach of this open dataset.

- **Suppliers and production information.** This information source includes all data about the supplies, and product modifications, in the bakery industry. These data are automatically collected through the Blockchain-supported marketplace. In order to encourage suppliers and bakery companies to share a complete product information across the entire value chain, in this marketplace supplying process are totally automated; so, the costs are highly reduced, and the benefits maximized. Using QR codes (printed in products) and, maybe, the mobile applications, this information will be recovered by users.

- **Users’ recommendations.** This bidirectional information source is directly generated by the recommender system. It connects customers among them, increasing their power and decision capability, while it also allows user-industry interactions; so bakery companies may capture that information to improve their products and processes (in a cheaper, faster and more efficient manner than the one performed today). Users’ voting and opinions may be also collected through the mobile applications, in a similar scheme as described before.

- **Ecological footprint sensing information.** This information source is generated by a hardware platform focused on capturing data about the resource (energy) consumption and the gas emission. This platform publishes data through a LoRa network, and a broker based on FIWARE technologies. These raw data are, then, processed in an Industry 4.0 platform to calculate the specific footprint for each product. The results are communicated to managers through a monitoring dashboard together with other relevant variables regarding the production process; so the decision making process may be faster and more efficient.

The resulting architecture and platform are the contribution of the bakery industry use case to the global DEMETER ecosystem. Through this ecosystem, in the context of the use case, five basic experiments are planned.

- **Experiment #1.** This experiment is focused on analyzing if the users’ satisfaction and QoE increases if customers employ the DEMETER mobile applications and consuming the information in the bakery product database.

- **Experiment #2.** This experiment determines if the bakery industry efficiency increases while using the Blockchain-enabled marketplace. Specifically, processes related to supplying and quality management. One indicator is monitored in this experiment: the data management cost.

- **Experiment #3.** This experiment is focused on analyzing if the users’ satisfaction and QoE increases if customers are provided with trustworthy and transparent information about the bakery value chain, suppliers and products. Basically, two indicators are monitored: transparency and users’ satisfaction.

- **Experiment #4.** This experiment studies if the bakery industry efficiency increases through the automatic capture of users’ recommendations and opinions introduced in the recommender system. With this experiment we are focusing on three indicators, such as feedback, feedback cost and reaction time

- **Experiment #5.** This experiment is focused on analyzing if the decision-making process in the bakery industry increases its efficiency thanks to dashboards where all
relevant variables about the production process are displayed. In this experiment, the decision-making cost indicator is basically analyzed.

C. Mobile applications for digital user-industry interactions

In this paper we are reporting the first experiment, focused on the first information source (bakery product database) and the first technological enabler (the mobile ecosystem and applications).

Two mobile applications were developed and deployed. Both applications were designed for Android operating system, as it is the most popular system in Europe (and Spain) nowadays. Moreover, both applications are able to capture the barcode of any CODAN product and deploy the information about it stored in the database (openFoodFacts). Additionally, any product may be searched by name or manufacturer. On both applications, users may create an account where their preferences, alarms, etc., are stored and maintained. Both applications, finally, display, basically, the same information (ingredients, allergens and nutritional data), although they may be some additional options.

However, some important differences between these two applications were introduced. The first mobile application (application A), in order to improve their availability and integration with other digital services, employs Firebase functionalities. Firebase is a Google Cloud microservice ecosystem to allow, for example, easy login or associating the personal preferences to a Google profile. Additionally, communities of users and friends may be created and maintained. In that way, if a user wants to migrate the application to a new device, the process is much easier. Figure 4 shows some screen shots of application A. In this application, moreover, users may value products using a five-stars system. Votes are global and referred to products (as a whole). This information, in this experiment, is local and is not shared with the bakery company, although (in future experiments) will be sent to CODAN (if the user allows it) to improve their internal processes.

Nevertheless, customers may be worried about non-European third parties (Google) accessing to their data. Thus, a second application (application B) was developed.

This second application only employs local resources, which reduces its flexibility. However, it is a multiplatform application, as both a web interface and a native Android application were provided. On the other hand, some extra functionalities have been added. For example, preferred shops for each product and their location may be displayed in a map. Besides, legal information is enriched with data about product sustainability when available. Figure 5 shows some screen shots of application B. Furthermore, in this second application, users may value the products (using like/dislike options), but with a higher granularity: user may indicate their opinion about each ingredient.

In order to let the potential users to learn about DEMETER project and these applications, two different workshops were organized as part of the experiment. Next section is focused on that experience.

IV. EXPERIMENT: METHODS AND MATERIALS

In order to communicate and explain the new digital enablers (mobile applications) to final users, as well as carry out an experiment (Experiment #1) where the users’ satisfaction was monitored, two different workshops were conducted during the first months of 2021.

During each workshop, participants were provided with a brochure describing the pilot, the use case and the enablers. Besides, a giant poster was displayed and a short presentation (supported by some slides) about DEMETER project was developed at the beginning. Provided brochures included three QR codes: the two first ones linked to both mobile applications and the third one linked to two surveys which users could answer in a row. In order to promote users to download the mobile applications, during the workshops a selection of CODAN products were distributed for free, so customers and participant could test the enablers during the activity. Because of COVID-19 restrictions, each workshop was developed in several shifts with (at maximum) fifteen...
participant per shift. The first workshop was developed at Universidad Politécnica de Madrid (see Figure 6), while the second one was developed by CODAN in their facilities.

All participants were encouraged to fill two different surveys, displayed in a row when reading the QR code on the brochure. The first survey was focused on the mobile ecosystem performance. Questions related to design, usability, execution failures, response time and new functionalities were included in this first survey. The objective is to evaluate the users’ QoE and satisfaction about the technological enabler. On the other hand, the second survey was focused on the shopping experience while using this mobile ecosystem and it the users’ satisfaction and QoE improves. In this second survey, questions were related to the final satisfaction about products when compared using the provided mobile applications, the confidence on the own decisions when assisted by those mobile applications, the perceived global QoE when using the mobile ecosystem and the trust on the provided information. Finally, both surveys included a final section where users could report free comments. Globally, participants answered sixty-eight questions.

Both surveys included some initial questions (five questions) about the lifestyle, characteristics, and preferences of participants, so they can be segmented into the different targets under study. Specifically, two different CODAN’s market target were analyzed: general public and healthy segment. Table I shows some of the most relevant questions in both surveys and the initial section. Besides, Table II shows the global and segmented number of participants, as well as their main social characteristics.

In order to make valid comparisons, the same surveys were answered by users of other (but similar) mobile applications and common (traditional) users. Table III shows the social characteristic of these control groups.

All questions were based on a Likert scale, where the lower mark (1) meant “totally disagree” and the higher one (5) meant “totally agree”. Surveys were collected using the Google forms cloud application, so final results were captured through a CVS format. The Likert scale enabled the simple mathematical processing of results. To do that, MATLAB 2019b software was employed. A hardware platform based on a Windows 10 operating system and Intel i7 processor was used. In order to compare free comments, simple clustering machine learning mechanisms were employed, to group reports with the same vision. Finally, a Mann-Whitney U test was employed to statistically compare the obtained results and conclude if the final users’ satisfaction and QoE increased thanks to the mobile ecosystem.

<table>
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<th>Section</th>
<th>Question</th>
<th>Responses</th>
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<td>Intro</td>
<td>Will you reject to buy a product if it has a red flag in the nutriscore?</td>
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<td>I think the app design is fancy and modern</td>
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<td>Survey</td>
<td>The app responses quickly to my interactions</td>
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<td>I can access and locate information I want to see very easily</td>
<td>[1-5]</td>
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<tr>
<td>Survey</td>
<td>I did not suffer any fatal fail while using the mobile app</td>
<td>[1-5]</td>
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<tr>
<td>Survey</td>
<td>I feel satisfied with my shopping decisions</td>
<td>[1-5]</td>
</tr>
<tr>
<td>Survey</td>
<td>I feel I have enough information to make an intelligent decision</td>
<td>[1-5]</td>
</tr>
<tr>
<td>Survey</td>
<td>I feel comfortable and amused while shopping</td>
<td>[1-5]</td>
</tr>
<tr>
<td>Survey</td>
<td>I feel provided information may not be real or correct</td>
<td>[1-5]</td>
</tr>
<tr>
<td>Survey</td>
<td>Please, let us know any other comment you have</td>
<td>Free text</td>
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<th>Standard deviation (age)</th>
<th>Women percentage</th>
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<td>Healthy segment</td>
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<td>Users other apps</td>
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<td>Traditional customers</td>
<td>47</td>
<td>37.4</td>
<td>10.9</td>
<td>48%</td>
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</table>

V. EXPERIMENT: RESULTS

Figure 7, Figure 8 and Figure 9 shows the results (responses) for the first survey. Responses from different users are considered (mobile application A, mobile application B and other previously existing mobile applications). Besides, results for the different market segments (general public and healthy) are analyzed, as well as global results.

As can be seen, in general, healthy segment (Figure 10) presents lower marks than the general public or the global analysis. This behavior is especially relevant regarding design, usability and new functionalities. Besides, in general, we can see that mobile application A is better valued than any other application (including mobile application B and previously
existing applications). This phenomenon may be seen in almost every indicator. Comments reported by customers and participants show that users belonging to the healthy segment require additional functionalities and services, deploying more information about the origin of products, nutritional values, etc. Besides, users from this target need advanced design and usability solutions, as they use those mobile applications as a professional tool.

In general, a heuristic evaluation seems to prove that the provided mobile applications improve the state of the art and increase the users’ satisfaction (regarding only the technological enabler). However, as boxplot are overlapped, a statistical test is required. Table IV shows the results from the Mann-Whitney U test for different significance values.

As can be seen, in general mobile application A shows a statistically relevant improvement in all indicators (except in the response time) for the general public target, while mobile application B does not show any relevant improvement in any target. Moreover, thanks to enriched information and new functionalities such as the geolocation of shops, the proposed mobile ecosystem shows a very relevant improvement in the users’ satisfaction for all targets regarding the introduced technological innovations. Thus, we can conclude the proposed ecosystem improves the users’ satisfaction compared to the existing technological enablers.

Now, we are focusing on the second survey. Figure 10, Figure 11 and Figure 12 shows the results (responses) for the second survey for the different market targets under study.

In general, for all market targets users’ responses are more positive when employing the proposed mobile ecosystem than when employing any other enabler. New and enriched information seems to increase the users’ satisfaction, confidence and QoE, especially in the healthy segment where customers are very demanding regarding the nutritional information. However, trust does not increase in the same proportion. Collected comments show some users are cautious about the fact that CODAN (a bakery company) was supporting the initiative, so they felt the information was not totally trustworthy. Furthermore, the increase is higher compared to traditional customers who do not use any technological enabler while shopping.

Although heuristic analyses show the users’ satisfaction is actually increasing, as boxplots are overlapped, a statistical analysis is essential. Table V shows the results from the
Mann-Whitney U test for different significance values and control groups.

TABLE V. SECOND SURVEY. RESULTS. STATISTICAL COMPARISON.

<table>
<thead>
<tr>
<th>Control group</th>
<th>Group</th>
<th>App</th>
<th>Satisfaction</th>
<th>Confidence</th>
<th>QoE</th>
<th>Trust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing app</td>
<td>General public</td>
<td>A</td>
<td>**</td>
<td>**</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>*</td>
<td>*</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Healthy</td>
<td>A</td>
<td>**</td>
<td>**</td>
<td>***</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>**</td>
<td>*</td>
<td>***</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Global</td>
<td>A</td>
<td>*</td>
<td>**</td>
<td>*</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Traditional</td>
<td>General public</td>
<td>A</td>
<td>**</td>
<td>**</td>
<td>***</td>
<td>NS</td>
</tr>
<tr>
<td>customers</td>
<td></td>
<td>B</td>
<td>**</td>
<td>*</td>
<td>***</td>
<td>NS</td>
</tr>
<tr>
<td>(no app)</td>
<td>Healthy</td>
<td>A</td>
<td>**</td>
<td>***</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>**</td>
<td>**</td>
<td>***</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Global</td>
<td>A</td>
<td>**</td>
<td>**</td>
<td>***</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>**</td>
<td>**</td>
<td>***</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>

NS not significant; * significant at p < 0.05; ** significant at p < 0.005; *** significant at p < 0.001.

As can be seen, the users’ satisfaction increases in a statistically significant way regardless the employed mobile application, the market target or the considered control group. This effect is also seen when analyzing the users’ confidence in their decisions (in this case the increase in very significant). The QoE also increase, in general. Although for general public already employing a mobile application not difference is observed. This increase is extremely significant compared to traditional customers not using any other technological enabler while shopping. Finally, as said, no significant difference is reported regarding the users’ trust on provided information.

Therefore, we can conclude the users’ satisfaction and QoE improves and increases when using the proposed mobile ecosystem.

VI. CONCLUSIONS AND FUTURE WORKS

In this paper we report the first results from DEMETER project. DEMETER is a European project focused on improving the efficiency of agri-food sector, according to Industry 4.0 principles. In this paper, we are describing the use case of DEMETER project focused on bakery industry. Five different experiments focused on sharing four different information sources, together with the corresponding tools to guarantee the reliability and transparency of that information, are planned.

Results show how users’ satisfaction highly increases when enriched and personalized production information about products is available through, for example, mobile applications. In the future, this mechanism will include more information from suppliers and other related agents to analyze if this also represents a relevant increase in the users’ satisfaction.
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