INTERNET OF FOOD & FARM

OVERALL LESSONS LEARNED REGARDING BUSINESS MODEL

WP 4

March 18th, 2021

A Qualitative Comparative Analysis of characteristics that contribute to business maturity of IoF2020 Use Cases

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PROJECT SUMMARY

The internet of things (IoT) has a revolutionary potential. A smart web of sensors, actuators, cameras, robots, drones and other connected devices allows for an unprecedented level of control and automated decision-making. The project Internet of Food & Farm 2020 (IoF2020) explores the potential of IoT-technologies for the European food and farming industry.

The goal is ambitious: to make precision farming a reality and to take a vital step towards a more sustainable food value chain. With the help of IoT technologies higher yields and better-quality produce are within reach. Pesticide and fertilizer use will drop, and overall efficiency is optimised. IoT technologies also enable better traceability of food, leading to increased food safety.

Nineteen use-cases organised around five trials (arable, dairy, fruits, meat and vegetables) develop, test and demonstrate IoT technologies in an operational farm environment all over Europe, with the first results expected in the first quarter of 2018.

IoF2020 uses a lean multi-actor approach focusing on user acceptability, stakeholder engagement and the development of sustainable business models. IoF2020 aims to increase the economic viability and market share of developed technologies, while bringing end-users' and farmers' adoption of these technological solutions to the next stage. The aim of IoF2020 is to build a lasting innovation ecosystem that fosters the uptake of IoT technologies. Therefore, key stakeholders along the food value chain are involved in IoF2020, together with technology service providers, software companies and academic research institutions.

Led by the Wageningen University and Research (WUR), the 100+ members consortium includes partners from agriculture and ICT sectors and uses open source technology provided by other initiatives (e.g. FIWARE). IoF2020 is part of Horizon2020 Industrial Leadership and is supported by the European Commission with a budget of €30 million.

EXECUTIVE SUMMARY

As Internet of Food and Farm 2020 is finished in March 2021, it is relevant to evaluate the business maturity of the products developed in the project's Use Cases (UCs). The WP4 team researched which characteristics, such as having insight into the market, contribute to business maturity.

A Qualitative Comparative Analysis (QCA) was performed, which is a case-based, qualitative, comparative research approach. The advantage of this method is that it allows for analysis of the combined effects of multiple characteristics of a case, enabling it to examine complex relations of cause and effect, i.e. business maturity.

Based on expert opinion complemented by scientific literature, five characteristics were identified and included as input variables in the analysis. Four of these characteristics are based on self-assessment by the UCs and expert opinion, namely: team performance, partner fit, availability of resources and market insight. The fifth characteristic, partner type, is based on the share of budget allocated to research organisations in the total budget. It represents the extent to which the UC was research oriented. This can be derived from the budget of the IoT project's finances. Scores on product readiness and exploitation readiness monitored for business development, were used as outcome variables for this research. Out of the 33 UCs 22 were included in the analysis.

Our research finding is that *a combination* of the characteristics good partner fit, good team performance, not being limited by a lack of resources, and market insight contributes to the development of a product which is ready to go to the market. This represents one but sufficient combination of characteristics to reach the outcome of having a product ready to the market. Other combinations of characteristics that are sufficient for having a ready product, have in common that these UCs do not have a research orientation. The analysis of the opposite result, not having a product ready to the market shows two paths which have the following characteristics in common: limiting resources and lack of market insight.

Drawing conclusions on what contributes to exploitation readiness is more complex as still few cases were being ready for exploitation. The analysis gives some indication that having a research orientation is found a sufficient path for not having the exploitation ready.

To digital innovation projects focussing on increasing business maturity we recommend the following:

1. Based on the findings that the combination of characteristics – a good partner fit, good team performance, not being limited by a lack of resources and market insight – contribute to the outcome of having a product ready. Innovation projects should not focus on a single characteristic, because it is the co-occurrence of the characteristics that has a beneficial impact on product development. Therefore, give sufficient attention to establishing a good fit between partners, acquiring resources, gaining market insight, and creating good team performance.

2. Pilots or projects developing IoT that do not have a research orientation add to more favourable development of product maturity, i.d. both the product readiness and the product's exploitation readiness.

3. We recommend starting to support and focus on market insight during the early stages of innovation. This is based on the finding that market insight is part of the combination of characteristics that contribute to product readiness.

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1. INTRODUCTION

The objective of this deliverable is to share recommendations concerning large-scale technological uptake. Specifically, we focus on what characteristics or combination thereof advances business maturity in pilot cases that develop and market such technologically innovative products and services.

Data-driven solutions are increasingly becoming part of everyday life. New technologies lead to increased volumes and types of available data, offering great opportunities to those determined to derive insights from its data. In the agri-food industry, we see opportunities such as precision farming, optimizing animal health, and creating traceability from farm to shelf. Such solutions contribute to solving social challenges faced by European food and farming sectors while increasing their sustainability.

Internet of Food & Farm 2020 (IoF2020) pursues these opportunities. As part of the European Union's Horizon 2020 research and innovation program, the project aims at accelerating the adoption of the Internet of Things (IoT) "in order to secure sufficient, safe and healthy food and to strengthen the competitiveness of farming and food chains in Europe". IoF2020 consists of 33 use cases (UCs), each carried out to develop propositions and business models for IoT technology in the following agri-food sectors: arable, dairy, fruits, vegetables, and meat.

The UCs consist of multiple organisations, business as well as research organisations. They started this project with TRL levels (4 to 6). These relatively high levels raised the expectation that there could be an opportunity to reach high business maturity levels close to market introduction. IoF2020 enabled UCs to further develop their products and supported both financially and with advice on product viability, business modelling, and market analysis. Additionally, the project provided a platform for interaction and exchange with other UCs.

With IoF2020 ending by March 2021, it is possible to review the business development maturity of the 33 UCs after four years and identify the drivers of this result. Insights in these drivers will increase our knowledge about the business development of innovations in IoF2020 and may contribute to future IoT innovation development in general. Our interest is to find a combination of drivers that contribute to the business maturity of the IoF2020 UCs.

The type of analysis that we apply is Qualitative Comparative Analysis (QCA) (Ragin, 1987). QCA is a case-based, qualitative, comparative research approach. The advantage of this method is that it allows for analysis of the combined effects of multiple characteristics of a case, enabling it to examine complex relations of cause and effect. We explain the analysis and this 'complexity' further in the methodology section. The method is apt for 10 to 100 comparable cases that have enough variation in characteristics and outcomes.

The research presented in this report was carried out in collaboration with work package 4 (WP4) that provided business support to the UCs during the project. The progress of the business maturity status of the UCs was monitored and documented in the UC classification tool. In our analysis, we look at what (combination of) UC characteristics have contributed to this (lack of) business maturity. The outcome of the analysis will be used to provide recommendations concerning large-scale IoT uptake.

This report is structured as followed, first, we describe the qualitative comparative analysis to inform the reader about this method. Secondly, we present our model by explaining how we arrived at our input and output variables. Thirdly, we explain the data collection process and data matrix after which we present the results in the fourth section. We complete this report in the fifth part with our conclusion, reflections, and recommendations.

2. QUALITATIVE COMPARATIVE ANALYSIS

This first section of the report provides a short explanation of the Qualitative Comparative Analysis (QCA).

QCA is a qualitative approach *and* data analysis technique that systematically compares qualitative case data to find causal relations between characteristics of cases and their outcome. It takes into account the different combinations of characteristics that are present in the cases. This is opposed to quantitative approaches that are more interested in net-effects of separate characteristics on the outcome (Pattyn et al, 2015). The application of QCA on IoF 2020 UCs was inspired by Ton (2017). He evaluated rural development programmes for market organisations to improve their market access and organisational strength. Ton (2017) used QCA among other methods to find out which characteristics of organisations contributed to their improved market access apart from the support of the programme. In our case, we are interested in which characteristics contribute to business maturity.

QCA may not only identify a single pattern of characteristics but also multiple patterns of characteristics that can lead to the same outcome. In the literature on QCA this is called 'equifinality': there may be more than one path (combination of characteristics) to reach a certain outcome (Schneider and Wagemann, 2012). Schneider and Wagenmann (2012) describe that QCA is to assume causal complexity, which means that causality is:

- Contextual (different characteristics may result in different outcomes),
- Equifinal (there may be multiple patterns of characteristics leading to the outcome),
- Conjunctural (a characteristic may work only in combination with others) and
- Asymmetric (the absence of a (pattern of) characteristics will does not mean that de outcome is absent).

To compare qualitative case data on characteristics and outcome, the data has to be transformed in numbers to make use of Boolean algebraic procedures in the analysis. The 0 and 1 are regarded as a score for membership: a case has a score of 1 when it is full member of the set with a specific characteristic or outcome, or 0 when it has no membership. If you choose to allow for fuzzy memberships values, like we do, it also allows numbers that reveal a condition is not fully present (the UC's set membership score is 0.67) and not fully absent (the UC's set membership score is 0.33).

As rule of thumb QCA allows an amount of characteristics that makes up about 25% of the total number of cases in the analysis (Hirzalla, 2019). As there are 33 UCs, we could include up to 8 characteristics.

The QCA literature refers to 'conditions' in order to indicate whether they sufficient and necessary (Figure 1):

- A condition is sufficient if, whenever the condition is present, the outcome is also present. If Y is the outcome and X the condition: X -> Y. E.g. we may find that a good team performance is a sufficient condition for business maturity. However, there can be cases that are members of the outcome but not the condition.

- A condition is necessary if, whenever the outcome is present, the condition is present. Y -> X. This would mean that all cases that have reached business maturity have good team performance. However, it is possible that cases are members of the condition, but not the outcome.

Although it is more common to refer to 'conditions' in a QCA, we have chosen to use 'characteristics'.

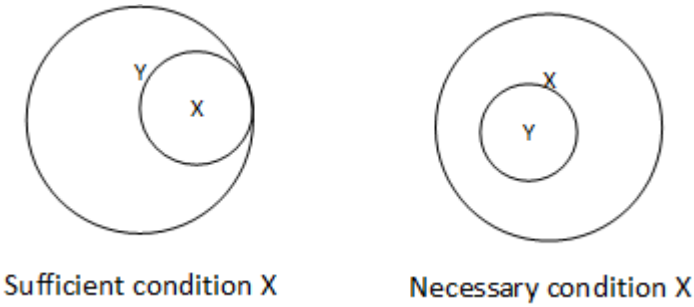

Figure 1. Venn diagram showing a sufficient condition X for the outcome Y (left) and a necessary condition X for the outcome Y (right).

3. DEFINING OUR MODEL

In this second part of the report we describe the model we used for the QCA and explain how we arrived at the characteristics and business maturity levels. We aim to find characteristics that explain the outcome 'business maturity level' of UCs. In the first section (3.1) of this chapter we explain that the characteristics are based on expert opinions complemented with scientific literature. In 3.2 we describe that business maturity was operationalised into two items (1) product readiness and (2) exploitation readiness. In the last section, 3.3, we present how the characteristics and outcome variables relate to IoF2020.

3.1. CHARACTERISTICS

To arrive at the characteristics that potentially explain the business maturity level, the following steps were executed:

- A focus group with experts on business development from Wageningen University and Research (WUR) discussed what characteristics could influence business development progress of IoT products. It resulted in a long list of 58 ideas and references to literature where possible.
- A short list of 8 characteristics (and sub-elements) was compiled in five iterative rounds by the project team to avoid overlap as much as possible.
- The WUR business development experts provided feedback on this list of potential characteristics and ranked the 8 characteristics on the order of impact they could have on overall high maturity of business development of IoT products (see Table 1).
- The characteristics and their sub-elements were operationalised into multiple choice questions for a survey. The rationale for this was that a survey would minimise the efforts of the UCs. The multiple-choice questions were designed in such a manner that the answer would indicate if the characteristic would be present, not fully present, absent or not fully absent. This allowed for the direct translation fuzzy values (Chapter 1) that provided input for the QCA analysis.

As a result, we derived a survey with 22 multiple choice survey questions and additional 9 questions that could be answered based on progress reports (See Annex I).

Table 1: characteristics driving business maturity in IoT development as ranked by the WUR business development experts.

Score	Characteristic
1.5 (most impactful)	Market insight
2.5	Understanding customer need
4.0	Team performance
4.3	Partner fit
4.7	Access to resources
6.2	Partner type
6.5	External stakeholder support
6.8	Types of funding
8.5 (least impactful)	Collaboration between UCs

The response to the survey (22 reactions) allowed us to include five characteristics in the QCA. Though 'understanding customer need' was initially proposed as a separate characteristic, we assigned it as element contributing to 'market insight'. The main argument for this decision is that customers are an integral part of the market. Collaboration between UCs and external stakeholder support were excluded due to low ranking and lack of evidence in the literature.

The characteristics that were included in the analyses are: market insight, team performance, partner fit, partner type, and resources. Theoretical background on these characteristics and how they were integrated in the survey are described below.

Market insight
In the focus group the experts underlined the importance for UCs to explore the market, establish the technology's competitive advantage and think about market position. This resulted in suggestions on whether the UC performed SWOT analysis, had market competition awareness, did cost benefit analysis, and applied the VRIN framework (valuable, rare, inimitable and non-substitutable). We grouped these suggestions together and summarised it as the characteristic 'market insight'. This characteristic was used to explore to what extent the UCs adopted a systematic approach to understand their customers and estimate their product's strengths and weaknesses, or alternatives to their product.

The survey therefore asked the UCs about:

- Activities UCs have done to gain market insights and to understand customer need
- The relative advantage of their product,
- Features of the product that that give relative advantage.

Partner type
Bain, Mann and Pirola-Merlo (2001) studied the relation between team climate, innovation, and performance. Their study confirmed that it is important to distinguish between different types of teams: research and development teams. Development teams scored higher on being useful while research teams attained higher creative outcome ratings (Bain et al., 2001, p. 69). The difference in scoring can be attributed to the differences in the type of work focus.

The UCs are composed of different organisations such as research institutes, universities, large enterprises, NGOs, and SMEs. In each UC, one organisation has taken lead, to connect the different organisational representatives and ensure the work gets done. The findings of Bain et al. (2001) give rise to the expectation that the composition of partners that make up the UC will impact the business development maturity differently. As one of the experts in the focus group put it: 'an academic environment might lead to less focus on market introduction'. Due to the potential difference in focus of research oriented organisations and business oriented organisation, we included the characteristic 'partner type'

Partner fit
How well the different organisations fit with each other will influence how UCs score on business development maturity. We refer to this characteristic as 'partner fit' which is made up by the following elements:

- Fit of partner competence
- Fit of organisational culture
- Fit of partner interest

The element partner competence refers to the presence and completeness of skills and resources among the individual partners that contribute to the UC objective. This is based on the book 'organisational behaviour' by Von Glinow & McShane (2015). A lack of skills and resources is expected to hinder the UC progress and, therefore, negatively impact the business development maturity.

The second element, organisational culture, is also based on Glinow & McShane (2015) as well as the self-assessment tool on how to manage innovation, that is provided by Tidd & Bessant (2013). According to Tidd & Bessant (2013), organisational culture concerns the extent to which organisations are geared towards sharing ideas and working together. When organisations have different organisational cultures, the expectation is that this will hinder business development.

The last element, the fit of partner interests, concerns how much the organisations individual goals hinder or complement those from other organisations in the UC. This is derived from the input from different experts who mentioned that conflicting interests among people who collaborate will influence the progress of business development of IoT products.

Together, partner competence, organisational culture and partner interest make up partner fit. The expectation is that in case of a bad fit this negatively impacts the business development maturity.

Although, we initially considered trust we decided not to include it as an additional characteristic or element. Trust is perceptual: we trust other on the basis of our beliefs on ability, integrity or reliability and benevolence (eTrust project, 2007; Glinow & McShane, 2015). High performing teams share high trust levels which are based on mutual understanding and emotional bonds (Glinow & Mc Shane, 2015) more than on predictability of the other team members behaviour or sanctions when members violate expectations. In other words, high performance teams share the same values and mental models. The elements organisational culture and fit of interest that are included in 'partner fit' sufficiently address these trust elements

Team performance
Because IoF2020 involves different people from diverse organisations from several countries, cooperation is central for the UC development. How the UC team functions and cooperates is captured in the characteristic 'team performance' which is made up by three elements:

- Stability
- Motivation
- Flexibility

Performance in new product development is generally benefited by team member stability unless there is a high degree of market and technical turbulence, in which case team instability can be advantageous (Akgün & Lynn, 2002, p. 263). Because the IoF2020 pilot was a four-year process it is possible there have been some changes in the team composition. In order to find out whether this influenced the UC business development we included a question about the extent the team composition changed.

Another important aspect of team performance is motivation as it stimulates and encourages team members to achieve their goals. When team members are motivated it creates an environment 'that fosters teamwork and collective initiatives to reach common goals or objectives' (Peterson, 2007, p. 60). As the UC strive to develop and improve products, the motivation of team members is likely to have a positive impact on their business maturity level.

The third and last element of the characteristics team performance focuses on team members' flexibility. It concerns the ability and willingness to respond to changes and setbacks. Studies (Chaharbaghi Adcroft & Willis, 2005; Kotter & Heskitt, Smit, 2015) reveal that flexibility and adaptability have a positive impact on innovation activities, which is why we believe that the more flexible and able to respond to setbacks and changes, the higher the UC business development maturity.

Resources
A lack of resources is a typical problem for enterprises who start out (Forsman, 2008, p. 606). 'Start-ups have a high need for resources yet face significant risks when forming partnerships with incumbents to access those resources.' (Knoben & Bakker, 2018, p. 103). Therefore, Knoben & Baker recommend strategic partnerships that can mitigate such risks through the versatility of relations.

While such a strategy has been adopted in IoF2020, as reflected by the organisational diversity of UC compositions, the question remains whether this has been sufficient to meet the resources needed for the UC objectives.

The characteristic 'resources' is comprised of the following elements:

- Finance/ funding
- Financial budgeting
- Intellectual resources
- Physical resources
- Test location availability
- External stakeholder support

We would like to know whether the UC feel they budgeted realistically and set viable targets with regards to the funding they received from the IoF2020 programme.

Additionally, the UC had to secure other resources such as buildings, vehicles, transportation, machines, patents, copyrights etc. Time spend looking for and securing these resources is time the UC could not spend on its product('s') business development. Therefore, our expectation is that the easier it was to secure resources the higher business development maturity.

3.2. BUSINESS MATURITY OF USE CASES

The outcome variable, business maturity, is based on the UC classification tool. This tool includes the following four elements:

- Product readiness - The extent to which the product development is beyond prototype and completely ready. Some actions may still be needed for it to be taken to the market.
- Business model readiness - The extent to which the UC has defined a business model for the developed product that is ready to be operational.
- Exploitation readiness - The extent to which the UC is ready to sell the developed product.
- Market readiness, ambition & success - The extent to which the developed product has active users and paying customers.

Table 2, below, presents the sub-elements that made up these four concepts.

We chose to only include the elements exploitation readiness and product readiness, because all UCs were expected to finalise their business model, while only a few UC products were ready for the market. This would mean that most UCs would have high business model readiness levels while very few would have high levels of market readiness. This would cause too little variation in the outcome for the QCA to be able to present meaningful results.

Therefore, we included product readiness and exploitation readiness to represent business maturity. Our focus of interest lies in the following two research questions:

- Which characteristics or combination of characteristics contribute to high levels of product readiness?
- Which characteristics or combination of characteristics contribute to high levels of exploitation readiness?

UC classification tool

The UC classification tool is one of the core products created by WP4. It allows for the monitoring and documenting of each IoF2020 use-case in terms its economic development.

The work package provided business support to each UC in the 5 trials (arable, dairy, fruit, meat and vegetable). Experienced business experts provided knowledge, skills and network connections to help shaping business models and asses market readiness.

At the beginning the UC monitoring and documenting was done through evolutionary template presentations visualizing the business model and written reports documenting concepts and action points. However, with the further progress of the UCs and the rather complex support on topics of business modelling, product development, user acceptance testing and impact measurement, WP4 developed a condensed and concise format for comparing the UCs and indicating their current development status: the UC classification tool.

The tool grew from an internal instrument to keep track of current developments in the UCs to get an overview into a progress classification tool from the business modelling perspective (not from a technical or end user perspective). The classification lists all products of IoF2020 UCs next to each other and applies to them the current maturity rating of each criterion. This way each team member of WP4 gets an easy and simple indication on the UC needs for specific support in their domain and how to distribute their support efforts among the UCs.

The classification follows an adjusted structure of a business model canvas. As several parts important to the UC were not included in the canvas, additional components were included in the classification (online and offline distribution structures and different products). Based on discussion with experts, categories contributing to these main topics were created and the different elements were assigned different weight to highlight crucial sections (see Table 2). The rating was filled in by the WP4 experts after several individual support calls with each use-case.

Table 2. Business readiness Classification

Exploitation Readiness	25%	Revenue Allocation Structure	40%
		Private Investment Triggered	10%
		Sales Experience & Abilities	20%
		Profitability	30%
Business Model Readiness	40%	Value Proposition	20%
		Payment & Pricing	20%
		Online Distribution Structure	15%
		Offline Distribution Structure	15%
		Online Customer Service Structure	15%
		Offline Customer Service Structure	15%
Product Readiness	25%	Input Data Integration Status	15%
		Output Data Integration Status	15%
		User Interface Status	15%
		User Acceptance	25%
		Mvp Cycle Status	10%
		Mvp Rollout	20%
Market Readiness, Ambition & Success	10%	Market Targeted	40%
		Customers With Necessary Infrastructure	10%
		Number Of Active Users	25%
		Number Of Paying Clients	25%

3.3. MODEL

Figure 2 represents the intervention logic of the IoF2020 in a general way. The project support comprises, besides business support, financial support and eco-systems support. Outcomes of the project are among others technical advancements of IoT products, improved eco-systems, interoperability and improved business maturity. So, our model just relates part of the project outcome (business maturity of UCs) to some UC characteristics. Above, these characteristics are connected to different phases in the IoF2020 project. The characteristic 'partner type' can be observed in the budget of the IoT project proposal. 'Team performance', 'partner fit' and 'resources' on other hand may be observed only during the IoT development process in the IoF2020 project. 'Market insight' may have been present in the organisations from the start but may also be developed during the project as a result of business model support. There may be other (causal) relations like between some characteristics, for example some type of organisations may have more market insight than others.

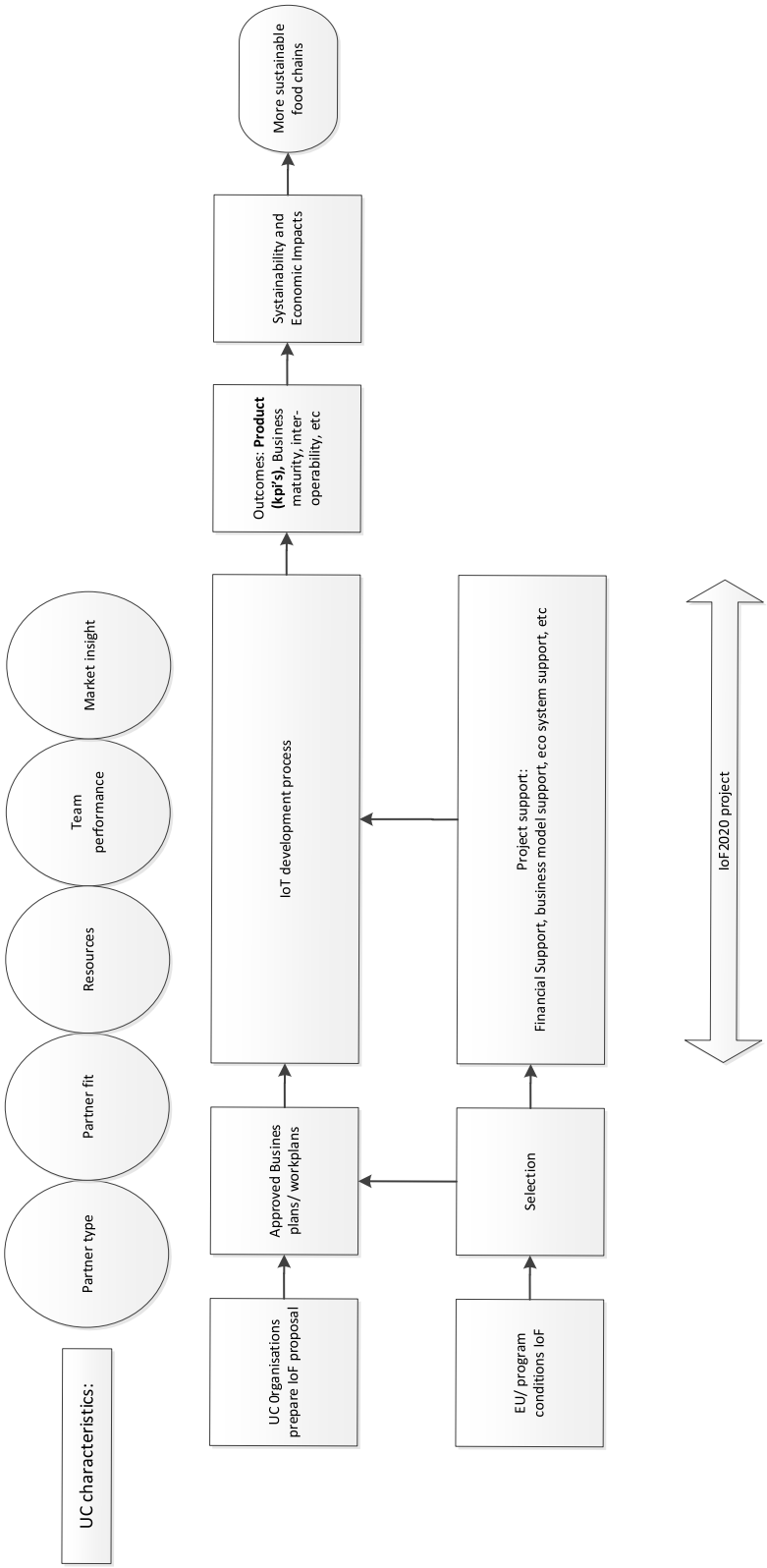

Figure 2. General overview of intervention logic of IoF2020.

4. DATA COLLECTION AND DATA MATRIX

In this chapter we describe how data was gathered and calibrated to fit the data matrix which forms a vital aspect of our analysis.

As described in the previous chapter, the UC characteristics partner fit, team performance, market insight, and resources are based on the online survey among the UCs (Annex 1). The survey is made up by 17 multiple choice questions with four response options, one multiple choice question with two response options, one multiple choice question that required rating of five elements, and three open questions. Making up a total of 22 questions. The decision to include four response options builds on the principles of the qualitative comparative analysis which was explained in 3.1.

The survey was distributed to the UCs by the team members of WP4 responsible for business support who formed the central point of contact for these UCs. This approach was chosen because this contact had already been established and to minimise efforts from UCs. In total 22 responses were recorded of the total 33 UC. Indicating a 64,71% response rate.

The data was extracted from Qualtrics, the host of the online survey, to Excel.

The characteristic 'partner type' of the UCs is based on the percentage of the total project budget that was allocated for research institutes and universities. The fact that companies got compensated 70% of their costs, was taken into account. Their own support of 30% was added to our calculated project budget. Partner type therefore reflects the research orientation in the UC.

As a first step in the QCA, we generate the so-called **data matrix** in which the data is converted into scores that indicate if the characteristic is present (1) or absent (0) or the in between fuzzy values 0.33 and 0.67. This is process is called calibration.

For the QCA the software fsQCA (version 3.1b) is used.
It is available on http://www.socsci.uci.edu/~cragin/fsQCA/software.shtml.

Calibrating the characteristics
We formulated the multiple choice answer options in such a way they directly translate to fuzzy scores. The first answer =0, the second =0.33 and the third and fourth are 0.67 and 1 respectively. We choose the lowest score of the elements to represent the score for the characteristics market insight, team performance, partner fit, and resources. This means that no element could compensate for the other, or e.g. partner fit is present if all elements are present. Below find the values for the characteristics for the 22 UCs that we were included in the analysis (Table 4). Table 3 explains the abbreviations.

Table 3. Explaining the abbreviations.

Set Name	Outcome/Characteristic	Meaning Set Membership	Theoretical concept
PR	Outcome	PR=1: Product ready	Product Readiness
EX	Outcome	EX=1: Exploitation ready	Exploitation Readiness
T	Characteristic	T=1: Research orientation	Partner Type
F	Characteristic	F=1: Good fit	Partner Fit
P	Characteristic	P=1: Good performance	Team Performance
R	Characteristic	R=1: No limiting resources	Resources
M	Characteristic	M=1: Good market Insight	Market Insight
UC	Use Case	-	-
~	Non-occurence	-	-

Table 4. Data matrix on the outcome product readiness (PR) and the outcome exploitation readiness (EX) and the five characteristics (survey/ self-assessment) for 22 UCs.

UC	PR	EX	T	F	P	R	M
1	0,67	0,67	0,33	0,67	0,33	0,33	0,33
2	1	0,33	0	1	1	0,67	1
3	0,67	0,67	0,33	0,33	0,33	0,67	0,33
4	0,67		0	1	0,67	0,67	0,67
5	1	0,67	0	0,67	0,67	0,67	0,67
6	0,67	1	0	0,67	0,67	0,67	1
7	0	0	1	0,33	0,67	0,33	0,33
8	0,33	0,67	0	0,67	0,67	0,67	0,67
9	0,67	0,67	0,67	0,67	0,67	0,67	0,67
10	0,67	0,67	0	0,67	0,67	0,67	0,67
11	0,67	0,33	0,67	1	1	1	1
12	1	0	0,33	1	1	0,67	1
13	0,33	0	0	0,67	0,67	0,33	0,67
14	0,67	0,67	0	0,67	0,67	1	1
15	0,67	0,67	0	0,67	0,67	0,67	1
16	0,33	1	0	0,67	0,67	0,33	1
17	0,67	0,33	0,33	0,67	0,67	0,67	0,33
18	0	0	0	0,67	1	0,33	0,33
19	0,67	0,33	0,33	1	0,67	0	0,67
20	1	0,67	0	0,67	0,67	0,33	1
21	0,67	1	0	0,67	0,67	0,33	0,67
22	0,33	0	0	0,67	1	0,67	0,67

Calibrating the outcomes

Data on the outcomes product readiness levels and exploitation readiness levels were retrieved from the UC classification (27 Feb 2021).

Based on the information on the product readiness of all UCs the classification score was translated as follows:

- Product readiness showed no or very little progress during the project (0) = product readiness up to 1.5
- Product readiness progressed a little during project (0.33) = product readiness smaller or equal to 2 (but above 1.5)
- Product readiness progressed considerably, but was lower than expected during the project (0.67) = product readiness smaller or equal to 3 (but above 2)
- Product readiness progressed to what could have been expected in the project time – up to being fully ready to the market (1) = product readiness level above 3

A product readiness level of 2 would be indefinite, right in between set membership in 'product ready' and not 'product ready'. The middle was confirmed by the WP4 project leader.

We used the calibration and the graph tool in fsQCA to find the other cut-off points. Figure 3 (left) shows the result of the calibration for 3.3 = membership of 0.95 in PR and 1 = membership of 0.05 in PR. The product readiness level of 2 coincidences with a gap in the more product ready UCs and those lagging behind. See also Table 3 for the values for product readiness.

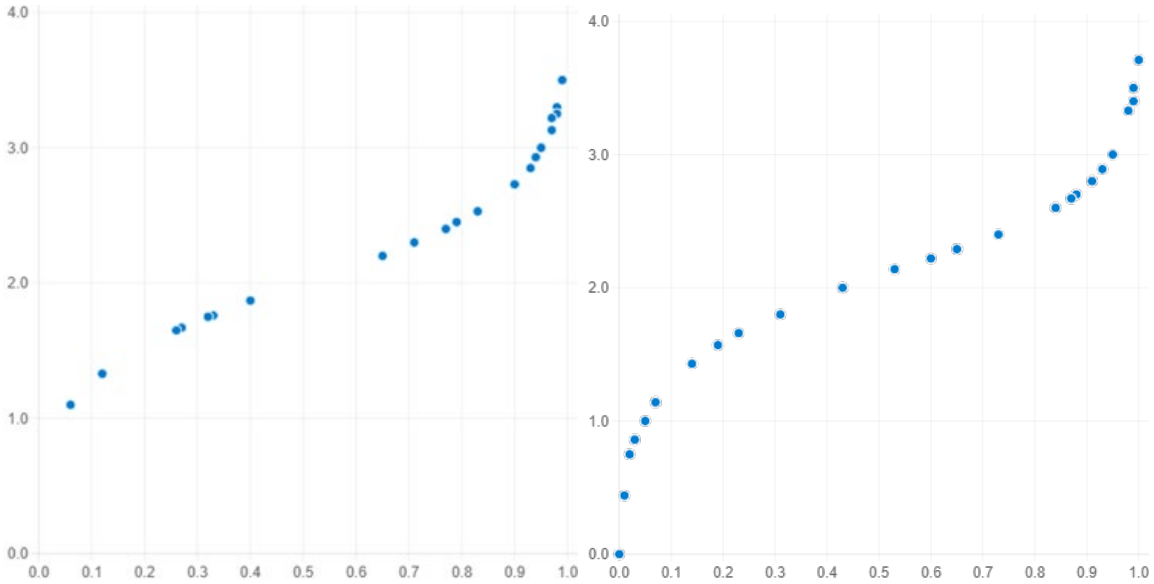

Figure 3. UC' product readiness scores versus membership in PR (left) and exploitation readiness scores versus membership scores EX (right).

The same procedure was for executed for exploitation readiness. The score for exploitation readiness from the UCs classification tool was translated as follows:

- Exploitation readiness showed no or very little progress during the project (0) = exploitation readiness up to 1.3
- Exploitation progressed a little during project (0.33) = exploitation readiness smaller or equal to 2.2 (but above 1.3)
- Exploitation progressed considerably, but was lower than expected during the project (0.67) = exploitation smaller or equal to 3 (but above 2.2)
- Exploitation progressed to what could have been expected in the project time – up to being fully ready to the market (1) = exploitation level above 3

So, an exploitation level of 2.2 would be indefinite, right in between set membership in exploitation ready and not ready. Figure 3 (right) shows the results of the calibration with the other cut-off points 3 = membership of 0.95 in EX and 1 = membership of 0.05 in EX. See Table 3 for the values for exploitation readiness.

We additionally asked the business experts of WP4 connected to the UCs to reflect on the values of the characteristics. We will do the analysis based on data from the self-assessment/survey and on the expert adjustments separately to see how stable the results are. Data matrices with expert adjustments are included in Annex II.

5. RESULTS

In this chapter we present the results of the different analyses we performed and explain how they can be interpreted.

After data calibration and creating the data matrix, the next step is to transform the data matrix into a truth table. This is the first step of the QCA. Each row in a truth table represents a logically possible configuration. In our case with 5 characteristics it would mean there will be 2^5 possibilities, so 32 rows. Each of the rows contains the truth table outcome value: this value is 1 if the outcome high readiness level is present and 0 if not. In the truth table below (Table 4), only rows were included that have at least one case to it. The 22 UCs in this analysis comprised 8 different configurations out of the logically possible 32 for the analysis on product readiness. The other 24 configurations are not present ('logical remainders') in the UCs. As a start we set the consistency level at 0.8, so only cases with a consistency level of 0.8 or more will be assigned to the outcome =1.

Figure 4 presents the concept of consistency and coverage for sufficient characteristics. In the upper left part, the consistency is b/(0+b) = 1; the consistency is lower on the right-hand side: only part of the cases with membership in X have outcome Y. In the bottom part the concept coverage is explained. Coverage revers to the number of cases with characteristic X to the total number of cases that have outcome. In the right lower corner, a less consistent sufficient characteristic.

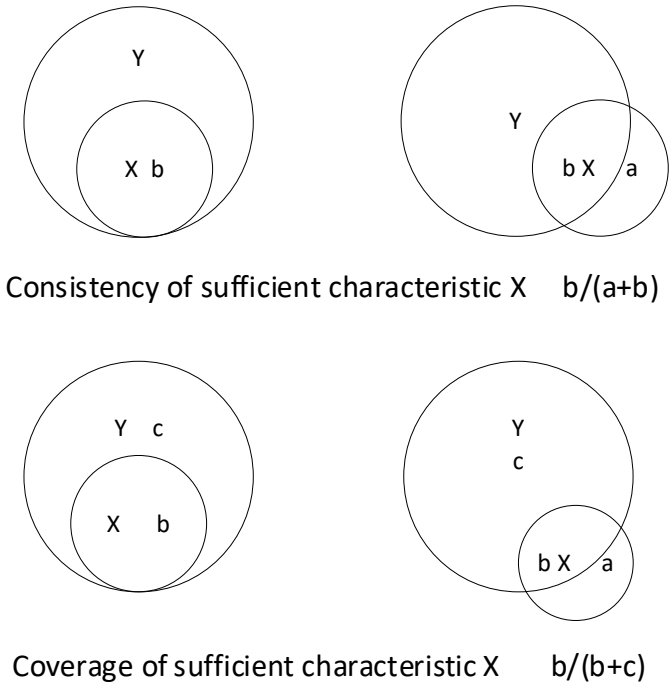

Figure 4: Venn diagrams explaining coverage and consistency of characteristic (condition) X and outcome Y.

Analysis Truth Table, Outcome: 'Product ready'

The level for raw consistency was set at 0.86 (instead of the usual 0.8), to exclude row 2 from getting the value 1 for the outcome PR. This row would otherwise be a row with only a contradictory case. The Truth Table (Table 4) shows that two configurations (combinations of characteristics) have the outcome PR=0. Six configurations have the outcome PR=1. One of the configurations includes 10 UCs that have the configuration of ~T, F, P, R, and M and have their product ready. ~T means the

non-occurrence of the research orientation. There are two UCs with the outcome product ready that have membership in just one characteristic.

Before we continue to analysis to find sufficient characteristics we check if we can find any necessary characteristics. Table 5 does not show any characteristic that only occurs when the outcome PR=1. But for PR=0, the table shows that P=1, R=0 and M=0 in both rows. We decided to the test for necessity for these characteristics in the non-occurrence of having a ready product (~PR). We find a consistency level of 0.96 that good team performance is a necessary condition for not having a ready product. Below we will come back to this.

A truth table for the non-occurrence of PR (~PR) was calculated. For this, the level for raw consistency was set at 0.86 (not to include two rows with a contradictory case). See truth table 6.

Table 5: truth table, outcome 'product ready' (PR) self-assessment.

Number of cases	PR	T	F	P	R	M	raw consistency
1	0	1	0	1	0	0	0.66
1	0	0	1	1	0	0	0.85
1	1	0	1	0	0	0	1
1	1	0	0	0	1	0	1
1	1	0	1	1	1	0	0.92
2	1	1	1	1	1	1	0.89
5	1	0	1	1	0	1	0.87
10	1	0	1	1	1	1	0.9

Table 6: truth table, outcome 'product not ready' (~PR) self-assessment

Number of cases	~PR	T	F	P	R	M	raw consistency
1	1	1	0	1	0	0	1
1	1	0	1	1	0	0	0.93
1	0	1	1	0	0	0	0.83
1	0	0	1	1	1	0	0.84
1	0	0	0	0	1	0	0.8
2	0	1	1	1	1	1	0.66
5	0	0	1	1	0	1	0.71
10	0	0	1	1	1	1	0.6

Finding a solution for the outcome having a 'product ready' UC self-assessment

Based on all configurations for which consistency has been confirmed in the truth table, the analysis focusses on finding sufficient configurations (combination of characteristics) for the outcome PR. All these configurations together are called a solution. This solution is found by manner of 'logical minimization' of a Boolean expression. This expression starts off with summing up all configurations for which consistency is confirmed, so all rows with PR=1. The solution which is based on the findings of the 22 cases is called the 'complex solution'. Based on the theoretical directions of the characteristics, the software also provides the most 'parsimonious solution' and an 'intermediate solution'. We assume on the theoretical grounds (Section 3.1) that when characteristics M, P, F and R are present, the outcome PR should also be present. On T we did not assume any direction as we do

not know whether a research or business orientation would lead to PR =1. The intermediate solution is the most useful (Schneider & Wagemann, 2012). The standard analysis in the fsQCA-software provides all three solutions. Below find (figure 5 and 6) the intermediate solutions for PR and ~PR. Annex III provides the other solutions.

Figure 5 shows that the outcome PR is realised through four paths. Paths are combinations of characteristics sufficient for the outcome: (1) the combination of ~T and R; (2) the combination of ~T, F and ~P, (3) the combination of ~T, F and M, or (4) combined characteristics F, P, R, M. The latter solution is not surprising because the configuration with characteristics F, P, R, M can be observed in the truth table in 12 out of 22 use cases (the rows with 2 and 10 UCs in the truth table). Two UCs out of these 12 are contradictory, meaning that their outcome suggests that they should not be included when PR=1. The first three solutions are characterised by having ~T, they have the non-occurrence of research orientation in common. Path 2 is covered by just one UC, but path 1 is covered by 12 UCs (of which two are contradictory) and path 3 is covered by 15 UCs of which 4 are contradictory.

The solution for ~PR only covers two UCs (see Figure 6) and both paths are covered by just one case. Both paths include good team performance. Above we even found that good team performance would be a necessary condition for not having a ready product. There is no logical explanation for this result. So we interpret both paths of the solution for ~PR: **Despite having good team performance they lacked resources and did not have good market insight.**

Overall, it can be concluded that the *combination* of characteristics: good partner fit, good team performance, no limiting resources and market insight is a sufficient path for the outcome of having a product ready. Not having a research orientation is part of the other three sufficient paths to have a product ready.

--- INTERMEDIATE SOLUTION ---

frequency cutoff: 1
consistency cutoff 0.873275

Assumptions:
F (present)
P (present)
R (present)
M (present)

	raw coverage	unique coverage	consistency
(1) ~T*R	0.723802	0.0508981	0.878293
(2) ~T*F*~P	0.420659	0.025449	1
(3) ~T*F*M	0.798653	0.101048	0.863269
(4) F*P*R*M	0.723802	0.0508982	0.852734

solution coverage: 0.925898
solution consistency: 0.821927

Figure 5. Solution for the self-assessment PR.

--- INTERMEDIATE SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.928726

Assumptions:
~F (absent)
~P (absent)
~R (absent)
~M (absent)

	raw coverage	unique coverage	consistency
(1) ~F*P*~R*~M	0.459491	0.0775463	0.923256
(2) ~T*P*~R*~M	0.497685	0.115741	0.928726

solution coverage: 0.575231
solution consistency: 0.937736

Figure 6. Solution for the self-assessment ~PR.

Finding a solution for the outcome having a 'product ready' expert opinion

We performed the analysis on the assessment done by the experts on the characteristics F, P and M. The data matrix is found in Annex II.

Except for one case, the experts were equally or more positive in their assessment than the self-assessment especially with regard to the UCs' market insight. This is reflected in truth table 8. The

consistency level was set at the usual 0.8. The row with 5 UCs in the table 5 is now a row of 6 and the row of 10 UCs became a row of 11. Now in total 13 cases reveal that the combination of characteristics F, P, R, and M that are connected to the outcome PR=1. Also the truth table reveals 6 instead of the 8 rows; there is less diversity in the cases.

Analysing truth table 8 there is not a characteristic that we could classify as necessary. Figure 7 shows the solution based on the consistent configurations. Solution coverage and consistency are lower than in the analysis based on self-assessment and now the solution consists of three paths. Path 3 is again the combined presence of F, P, R, and M. From the 13 cases in that path two are contradictory. And similar to the self-assessment solution, the other paths (1 and 2) are characterised by the non-occurrence of research orientation, though in combinations with different of other characteristics. The first path is covered by 18 UCs, but 5 of them are contradictory. Path 2 is covered by 12 UCs of which 2 are contradictory.

Table 9 and Figure 8, show the truth table and intermediate solution for the non-occurrence of PR. The usual cut off for consistency of 0.8 is used[1]. We find the solution coverage is low. The solution consists of two paths that are both covered by one case each. In the first path this UCs is even contradictory to the outcome.

This analysis shows that the solution is sensitive to the different values of the characteristics for rows with low numbers of cases. Especially for the negated outcome we find a different solution.

However, **the combination of good partner fit, good team performance, no limiting resources and market insight is a sufficient path for the outcome of having a product ready is underlined by the assessment based on expert views. Also, not having a research orientation is part of the other two sufficient paths to reach the outcome of a ready product. And again, the combination of limiting resources and lack of market insight is part of both paths of the solution in the analyses of not having a product ready.**

Table 8: truth table, outcome 'product ready' (PR) expert opinion

Number of cases	PR	T	F	P	R	M	raw consistency
1	0	1	0	1	0	0	0,75
1	1	0	0	0	1	1	0,93
1	1	0	1	0	0	0	0,91
2	1	1	1	1	1	1	0,89
6	1	0	1	1	0	1	0,84
11	1	0	1	1	1	1	0,90

Table 9: truth table, outcome 'product not ready' (~PR) expert opinion

Number of cases	~PR	T	F	P	R	M	raw consistency
1	1	1	0	1	0	0	0,88
1	1	1	0	0	0	0	0,82
1	1	0	0	1	1	0	0,80
2	0	1	1	1	1	1	0,66
6	0	1	1	0	1	0	0,72
11	0	1	1	1	1	0	0,58

[1] To realise the mirrored outcome of truth table 8 the raw consistency cut off should have been 0.86. Row 2 and 3 have contradictory cases.

--- INTERMEDIATE SOLUTION ---

frequency cutoff: 1
consistency cutoff 0.837545

Assumptions:
F (present)
P (present)
R (present)
M (present)

	raw coverage	unique coverage	consistency
(1) ~T*F	0.82485	0.126497	0.803793
(2) ~T*R*M	0.723802	0.025449	0.878293
(3) F*P*R*M	0.749251	0.0508982	0.857021

solution coverage: 0.901198
solution consistency: 0.765903

Figure 7. Solution for the expert outcome PR

--- INTERMEDIATE SOLUTION ---

frequency cutoff: 1
consistency cutoff 0.815934

Assumptions:
~F (absent)
~P (absent)
~R (absent)
~M (absent)

	raw coverage	unique coverage	consistency
(1) ~T*~P*~R*~M	0.34375	0.152778	0.815934
(2) T*~F*~R*~M	0.268519	0.0775463	0.875472

solution coverage: 0.421296
solution consistency: 0.844548

Figure 8. Solution for the expert outcome ~PR

Analysis Truth Table, Outcome 'Exploitation Ready'

To generate the truth table on exploitation readiness the usual cut off point 0.8 was maintained. Table 10 shows that there are two configuration that have the outcome EX=1 (having the exploitation ready). For finding necessary characteristics we checked if the outcome is related to specific characteristics. Table 10 shows that for EX=1, T=0, P=0, and M=0. When EX=0, P=1.The analysis for necessity shows that in ~T (not having a research orientation) seems a necessary condition for reaching exploitation readiness (consistency 0.97) and good team performance for not reaching exploitation readiness (consistency level 0.92). We come back to these findings when discussing the solutions.

Finding a solution for the outcome 'ready product exploitation' self-assessment

We continue the analysis for finding sufficient paths for characteristics for EX. By logical minimization and assuming the direction as before: when M, P, F and R are present, the outcome EX is also present. On T we did not assume any direction as we do not know it research or business orientation will lead to EX is present. For EX=1 the solution was calculated, and two paths were found. (Figure 9). These paths are both characterised by an absence of research orientation (T=0) and the absence of a good team performance (P=0), which is contra-intuitively. These paths are both covered by one case only. Both these cases are not contradictory however. **Both paths to have the exploitation ready, have the characteristic in common not having a research orientation.**

The intermediate solution for ~EX=1 presents two sufficient paths (Table 11 and Figure 10). One path says that T (research orientation) is a sufficient path for not being exploitation ready. This path is covered by three UCs of which one is contradictory. The other says that P and ~M combined is a sufficient path. This path is covered by three cases and of which none is contradictory. If P would have been really necessary, we would expect to find this characteristic in both paths. Besides the path having a research orientation and good team performance the path not having market insight is a sufficient path for not realising a ready exploitation.

Table 10: truth table, outcome exploitation ready (EX) self-assessment

Number of cases	EX	T	F	P	R	M	raw consistency
1	1	0	1	0	0	0	0,91
1	1	0	0	0	1	0	0,9
1	0	0	1	1	0	0	0,69
1	0	0	1	1	1	0	0,66
1	0	1	0	1	0	0	0,66
2	0	1	1	1	1	1	0,67
5	0	0	1	1	0	1	0,74
9	0	0	1	1	1	1	0,75

Table 11: truth table, outcome exploitation not ready (~EX) self-assessment

Number of cases	~EX	T	F	P	R	M	raw consistency
1	1	1	0	1	0	0	1
1	1	0	1	1	0	0	0,92
1	1	0	1	1	1	0	0,92
1	1	0	1	0	0	0	0,82
2	1	1	1	1	1	1	0,89
1	0	0	0	0	1	0	0,8
5	0	0	1	1	0	1	0,74
9	0	0	1	1	1	1	0,68

```
--- INTERMEDIATE SOLUTION ---

frequency cutoff: 1
consistency cutoff 0.900302

Assumptions:
F (present)
P (present)
R (present)
M (present)
                    raw          unique
                    coverage     coverage     consistency
                    ----------   ----------   ----------
(1) ~T*F*~P         0.479227     0.0647343    0.937618
(2) ~T*~P*R         0.447343     0.0328503    0.933468

solution coverage: 0.512077
solution consistency: 0.941385
```

Figure 9. Solution for the self-assessment EX

```
--- INTERMEDIATE SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.886288

Assumptions:
~F (absent)
~P (absent)
~R (absent)
~M (absent)
                    raw          unique
                    coverage     coverage     consistency
                    ----------   ----------   ----------
(1) T               0.342723     0.124883     0.914787
(2) P*~M            0.467606     0.249765     0.937853

solution coverage: 0.592488
solution consistency: 0.904011
```

Figure 10. Solution for the self-assessment ~EX

Finding a solution for the outcome 'ready product exploitation' expert opinion

We performed the analysis in a similar manner for experts' data. The consistency cut off is the usual 0.8. Table 12 shows the truth table for the outcome EX. There is only one configuration where EX=1. For EX=0: F=1, T=1 and M=1. We analysed if these characteristics were necessary, but none reached even the consistency level of 0.9.

Figure 11 shows the intermediate solution for the outcome having the exploitation ready, which is one path (~T*~F*R*M) that is covered by just one UC.

A truth table was made for the non-occurrence of EX (~EX), see Table 13. The cut off point for consistency is 0.8. To find sufficient characteristics the solution was calculated. Figure 12 shows the intermediate solution that consist of two paths: (1) T, covered by three cases of which one is contradictory. The other path (2) ~P~R~M is covered by one and contradictory case only.

Table 12: truth table, outcome exploitation ready (EX) expert opinion

Number of cases	EX	T	F	P	R	M	raw consistency
1	1	0	0	0	1	1	0,8
1	0	1	0	1	0	0	0,62
1	0	0	1	0	0	0	0,7
2	0	1	1	1	1	1	0,67
6	0	0	1	1	0	1	0,71
10	0	0	1	1	1	1	0,72

Table 13: truth table, outcome exploitation not ready (~EX) expert opinion

Number of cases	~EX	T	F	P	R	M	raw consistency
1	1	1	0	1	0	0	1
1	1	0	1	0	0	0	0,9
2	1	1	1	1	1	1	0,89
1	0	0	0	0	1	1	0,8
6	0	0	1	1	0	1	0,75
10	0	0	1	1	1	1	0,69

--- INTERMEDIATE SOLUTION ---

frequency cutoff: 1
consistency cutoff 0.800403

Assumptions:
F (present)
P (present)
R (present)
M (present)

	raw coverage	unique coverage	consistency
(1) ~T*~F*R*M	0.479227	0.479227	0.833613

solution coverage: 0.479227
solution consistency: 0.833613

Figure 11. Solution for the expert opinion EX .

--- INTERMEDIATE SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.886288

Assumptions:
~F (absent)
~P (absent)
~R (absent)
~M (absent)

	raw coverage	unique coverage	consistency
(1) T	0.342723	0.125822	0.914787
(2) ~P*~R*~M	0.309859	0.0929577	0.906593

solution coverage: 0.435681
solution consistency: 0.87218

Figure 12. Solution for the expert opinion ~EX

This analysis shows, again, that the solution is sensitive for the different values of the characteristics. In analysing the exploitation readiness, the results on the negated outcomes are somewhat more stable, due to the fact that there are more UCs not having exploitation ready. The analysis based on expert assessment confirms the indication that **having a research orientation is found a sufficient path for not having the exploitation ready.**

6. CONCLUSION AND RECOMMENDATIONS

Conclusion

We analysed what combination of characteristics contributed to product readiness and exploitation readiness to derive what advances UC business maturity.

The characteristics used in the analysis were based on self-assessment by the UCs and on expert opinion. In some cases, the expert view diverted from this self-assessment. With a few exceptions, the expert assessment was more positive, especially on the characteristic of market insight. Though the analyses was sensitive to these different attributed values, we can conclude the following on the on the contribution of the characteristic to business maturity.

- In relation to product readiness:
  - The combination of the characteristics a good partner fit, good team performance, not being limited by a lack of resources and market insight contributes to the outcome of having a product ready to go to market. It is a sufficient path to the outcome.
  - The other sufficient paths include the characteristic of not having a research orientation. This means that not having a research orientation contributes to having a product ready.
  - The two cases that did not have a product ready, have in common that despite their good team performance they lacked resources and did not have good market insight.

- In relation to exploitation readiness:
  - Drawing conclusions on what contributes to exploitation readiness is more complex as the analysis provides more insight on what characteristics contribute to products not being ready for exploitation.
  - However, the solutions presented for this outcome (product not ready for exploitation) is only covered by few cases.
  - Despite these difficulties and concerns, both the analysis based on self-assessment by the UCs and expert assessment indicate that not having a research orientation is a sufficient explanation for a product not being ready for exploitation.

Reflection on the QCA

QCA is an appropriate analysis when there is enough variation in both the outcome as the characteristics. Though at first sight the data matrix seemed to contain variation, especially when analysing product readiness, we noticed that the analysis for characteristics that contribute to the outcome of not having a product ready, the paths are covered by just a small number of cases. We could have tried to adjust the levels of product readiness for membership of the outcome product ready. However, this is not a guarantee for better results in itself: the exploitation readiness is more varied in the outcome, but it did not bring results that were more clear. To increase variation we might include characteristics that, when present, do not contribute to the outcome to vary in the characteristics.

We are well aware that this QCA could have been enriched by investigating contradictory cases in the paths and trying to solve these contradictions. Contradictory cases are those that are included in the row with an outcome that is not supported by their own outcome. Also finding out more about the paths that are covered by just one UC might be a source of information. Or finding out more about the scattered results in the analysis on exploitation readiness. It requires time and effort to back to the cases and discuss the outcomes with experts. Unfortunately this was not possible within the time span of the project.

Recommendations

Based on the conclusions we recommend the following to other innovation pilots or projects similar to IoF2020 that develop and market IoT products:

Firstly, based on the findings that the combination of characteristics – a good partner fit, good team performance, not being limited by a lack of resources and market insight – contribute to the outcome of having a product ready. Innovation projects should not focus on a single characteristic, because it is the co-occurrence of the characteristics that has a beneficial impact on product development. Therefore, give sufficient attention to establishing a good fit between partners, acquiring resources, gaining market insight, and creating good team performance. Thus, we recommend stimulating and assisting in the following aspects:

- UCs are based on technical fit of participants – the project could also pay attention to the diversity of (organisational) culture and interests within the UCs.
- The project could also monitor the stability in the team and pay attention to the status of motivation within the UCs.
- There could be a check on realistic budgeting and the realistic claim on other resources in the project proposal.
- Market insight may be validated by stories of actual needs of potential customers, showing the market in sight and needs of customers.

Secondly, pilots or projects developing IoT that do not have a research orientation add to more favourable development of product maturity, i.d. both the product readiness and the exploitation readiness. This recommendation confirms the observation of one of the experts who previously cited in 3.1: ‘an academic environment might lead to less focus on market introduction’. Therefore, digital innovation projects are advised to look for a diversity of organisation types.

Thirdly, we recommend starting to support and focus on market insight during the early stages of innovation. This is based on the finding that market insight is part of the combination of characteristics that contribute product readiness.

Lastly, we recommend to start early when performing a QCA analysis as part of an evaluation. This will allow for enough time to include the experts in the process and to be able to discuss outcomes per case in order to have richer results.

REFERENCES

Akgün, A. E., & Lynn, G. S. (2002). Antecedents and consequences of team stability on new product development performance. Journal of Engineering and Technology Management, 19(3-4), 263-286.

Bain, P. G., Mann, L., & Pirola-Merlo, A. (2001). The innovation imperative: The relationships between team climate, innovation, and performance in research and development teams. Small group research, 32(1), 55-73.

Chaharbaghi, K., Adcroft, A. & Willis, R. (2005). Organisations, Transformability and the Dynamics of Strategy. Management Decision, 43(1), 6-12.

Forsman, H. (2008). Business development success in SMEs: a case study approach. Journal of Small Business and Enterprise Development.

Knoben, J., & Bakker, R. M. (2019). The guppy and the whale: Relational pluralism and start-ups' expropriation dilemma in partnership formation. Journal of Business Venturing, 34(1), 103-121.

Kotter, J. P., & Heskett, J. L. (1992). Corporate Culture and Performance. Free Press, New York, NY.

McShane, S. L., & Von Glinow, M. A. (2015). Organizational Behavior 7/e. McGraw-Hill Education.

Osterwalder, A., & Pigneur, Y. (2010). Business model generation: a handbook for visionaries, game changers, and challengers. John Wiley & Sons.

Pattyn, V., L.M.Gerrits en S.Stefan Verweij (2015), Qualitive Comparative Analyses: meer behorend bij de kwalitatieve dan de kwantitatieve benadering. In Kwalon, 20 (3), 26-33.

Peterson, T. M. (2007). Motivation: How to increase project team performance. Project management journal, 38(4), 60-69.

Hirzalla, F. (2019) Introduction to QCA. Erasmus Graduate School of Social Science and the Humanities, EUR.

Schneider, C. Q., & Wagemann, C. (2012). Set-theoretic methods for the social sciences: A guide to qualitative comparative analysis. Cambridge University Press.

Smit, J. (2015). The innovation value chain and adaptability of organizations. Journal of International Technology and Information Management, 24(3), 4.

Ton, Giel (2015). Measuring Tensions and Intentions- Mixing Methods in impact evaluation of development support to farmer organisations, PhD-thesis, Wageningen University.

ANNEX I: IOF2020 SURVEY

Dear IoF2020 participant,

The objective of this survey is to identify how Use Cases directed their efforts during the pilot. The survey outcome will contribute to a better understanding of where targeted assistance is needed to further expediate the process of business development of IoT innovations in the agri-food sector.

We ask you about market and customer awareness, team performance, (external) partner collaboration, and resources. This input will be compared with business development scores on exploitation, business model, product, and market readiness. We aim to find out whether the input leads to higher business development maturity.

Filling out the survey will take approximately 10-15 minutes, please select the answer that best describes the Use Case situation. Your data will be processed anonymously, and the results of the survey will be shared.

Thank you so much in advance!

1	What is the number and title of your Use Case?	
	Question 2 to 4 contribute to an understanding of the Use Case awareness about the market of their respective product(s)/ service(s).	
2	What has the Use Case done during IoF2020 to gain market insight? Use case performed market research and/ or analysis:	But no strategy based on that was formed
		Strategy based on that was formed but not implemented
		Strategy based on that was formed and implemented
		Strategy based on that was formed, implemented and evaluated
3	What is the relative advantage of Use Case product(s) compared to existing ones/ status quo? The product/ service:	Hardly offers benefits over existing products/ services
		Offers some benefits compared to existing products/ services
		Offers clear benefits compared to existing products/ services
		Offers significant benefits compared to existing products/ services
4	Please select five competitive advantages that are most applicable to your product/ service. In case of multiple products/ services, please make the selection based on your most successful product/ service.	Higher yields (in quantity)
		Improved quality of end product

		Reduced inputs (incl. labour force, lower treatment cost, monitoring costs)
		Reduced storage /process / dwell time during production
		Better advice/ improved managerial overview
		Ease of use
		Speed of operations
		Automated data collection
		Predictive data analytics
		Interoperability (ability to connect, exchange and make use of information from other products/ services)
		(Expected) product price/investment
		(Expected) reliability
		(Expected) service
	Question 5 and 6 contribute to an understanding of the use case awareness about the needs of customers (those who will potentially buy the product/ service) and end-users (those who will potentially use the product/ service).	
5	What has the Use Case done to understand the customer need? Use Case performed customer research and/ or analysis:	But no strategy based on that was formed
		Strategy based on that was formed but not implemented
		Strategy based on that was formed and implemented
		Strategy based on that was formed, implemented and continuously checked
6	During which of the phases did the Use Case consult end-users or perform end-user research? Multiple answers can be selected.	Ideation
		First minimum viable product (less than 25% of planned features)
		Second minimum viable product (between 25%-50% of planned features completed)
		Third minimum viable product (between 50%-75% of planned features completed)
		Final product (100% of planned features completed)
		No end-users consulted or end-user research performed
		Other, namely:
	Question 7 to 11 contribute to an understanding of the Use Case team and its efficiency.	
7	How many people work with the Use Case (including the Use Case leader)?	

8	To which extent did the composition of the people working with the Use Case stay the same?	Composition has constantly changed during the pilot (>33.3% of initial people working with the Use Case are not part of current team)
		Many people have joined and left during the pilot (<33.3% of people working with the Use Case are not part of current team)
		Some people have joined and left during the pilot (<25% of initial people working with the Use Case are not part of current team)
		No changes among people working with the Use Case
9	How did the skills and knowledge develop of the people working with the Use Case during the IoF2020 pilot? People working with the Use Case have developed:	Limited valuable new skills/knowledge
		Little but some valuable new skills/knowledge
		Clear valuable new skills/knowledge
		Significant valuable new skills/knowledge
		I do not know
10	How dedicated are the people working with the Use Case? The people working with the Use Case:	Often do not do what they agree to or finish the work later than planned
		Do what is agreed but put in minimal effort
		Put in the effort needed to perform the task at hand in time
		Put in great effort and regularly take on extra tasks or finish their tasks before the deadline
11	When presented with setbacks and/or changes the people working with the Use Case:	Stick to the original plan
		Are willing to somewhat deviate from the original plan
		Are adaptive in showing ideas for addressing them
		Are adaptive in showing ideas and start to implement these ideas
	Question 12 to 16 contribute to an understanding of the collaboration between the Use Case partners and stakeholders outside IoF2020.	
12	Use Case partners generally provided:	Poor skills and resources
		Moderate skills and resources
		Good skills and resources
		Excellent skills and resources
13	Individual cultures and work practices of partners:	Are incompatible and hinder Use Case progress
		Sometimes hinder Use Case progress

		Often align, having a positive effect on Use Case progress
		Align in a manner that positively affects Use Case progress
14	The individual goal(s) of partners:	Hinder Use Case progress
		Somewhat hinder Use Case progress
		Mostly complement each other, having a positive effect on Use Case progress
		Nicely complement each other in a manner that accelerates Use Case progress
15	To which extent did the Use Case receive any external stakeholder support? (Partners outside the IoF2020 pilot, i.e.: municipalities, industry companies, etc.)	The Use Case did not receive any external stakeholder support
		The Use Case wanted external stakeholder support but did not receive this
		The Use Case wanted external stakeholder support but only partially received this
		The Use Case has received external stakeholder support when needed
16	Please name the type(s) of external stakeholder(s) and what support they provided. (I.e.: test farm for testing and validating Use Case product/ service.)	External stakeholder 1:
		External stakeholder 2:
		External stakeholder 3:
		External stakeholder 4:
		External stakeholder 5:
		External stakeholder 6:
		External stakeholder 7:
		External stakeholder 8:
		External stakeholder 9:
		External stakeholder 10:
	Question 17 to 22 contribute to an understanding of the Use Case's (search for) resources.	
17	How well did the Use Case budget all financial resources?	Budget was too tight which resulted in not being able to realise proposed actions
		Budget was a little tight but did not affect proposed actions
		Budget was somewhat generous but did not allow for additional actions
		Budget was overly generous, which made it possible to realise additional actions

18	How easy was it for the Use Case to secure intellectual resources? (i.e.: brand, patents, copyrights, etc.)	It was extremely difficult, because:
		It was somewhat difficult, because:
		It was relatively easy, because:
		There was no trouble securing intellectual resources, because:
19	How easy was it for the Use Case to obtain physical resources? (i.e.: buildings, vehicles, transportation, machines, cameras, sensors, computers, etc.)	It was extremely difficult, because:
		It was somewhat difficult, because:
		It was relatively easy, because:
		There was no trouble securing physical resources, because:
20	How easy was it for the Use Case to acquire software?	It was extremely difficult, because:
		It was somewhat difficult, because:
		It was relatively easy, because:
		There was no trouble acquire software, because:
21	How easy was it for the Use Case to find a test location?	It was extremely difficult, because:
		It was somewhat difficult, because:
		It was relatively easy, because:
		There was no trouble securing test locations, because:
22	Is the Use Case currently looking for a test location?	No
		Yes

ANNEX II: DATA MATRIXES

Data matrix on the outcome product readiness and characteristics (self-assessment).

Nr.	PR	T	F	P	R	M
1	0,67	0,33	0,67	0,33	0,33	0,33
2	1	0	1	1	0,67	1
3	0,67	0,33	0,33	0,33	0,67	0,33
4	0,67	0	1	0,67	0,67	0,67
5	1	0	0,67	0,67	0,67	0,67
6	0,67	0	0,67	0,67	0,67	1
7	0	1	0,33	0,67	0,33	0,33
8	0,33	0	0,67	0,67	0,67	0,67
9	0,67	0,67	0,67	0,67	0,67	0,67
10	0,67	0	0,67	0,67	0,67	0,67
11	0,67	0,67	1	1	1	1
12	1	0,33	1	1	0,67	1
13	0,33	0	0,67	0,67	0,33	0,67
14	0,67	0	0,67	0,67	1	1
15	0,67	0	0,67	0,67	0,67	1
16	0,33	0	0,67	0,67	0,33	1
17	0,67	0,33	0,67	0,67	0,67	0,33
18	0	0	0,67	1	0,33	0,33
19	0,67	0,33	1	0,67	0	0,67
20	1	0	0,67	0,67	0,33	1
21	0,67	0	0,67	0,67	0,33	0,67
22	0,33	0	0,67	1	0,67	0,67

Data matrix on the outcome product readiness and characteristics (expert opinion).

Case Number	PR	T	F	P	R	M
1	0,67	0,33	0,67	0,33	0,33	0,33
2	0,33	0	0,67	1	0,67	1
3	0,67	0,33	0,33	0,33	0,67	0,67
4	na	0	1	0,67	0,67	0,67
5	0,67	0	0,67	1	0,67	0,67
6	1	0	0,67	0,67	0,67	1
7	0	1	0,33	0,67	0,33	0,33
8	0,67	0	0,67	0,67	0,67	0,67
9	0,67	0,67	0,67	0,67	0,67	0,67
10	0,67	0	0,67	0,67	0,67	1
11	0,33	0,67	1	1	1	1
12	0	0,33	0,67	0,67	0,67	0,67
13	0	0	0,67	0,67	0,33	0,67
14	0,67	0	0,67	0,67	1	1
15	0,67	0	0,67	0,67	0,67	1
16	1	0	0,67	0,67	0,33	1
17	0,33	0,33	0,67	0,67	0,67	0,67
18	0	0	0,67	0,67	0,33	0,67
19	0,33	0,33	0,67	0,67	0	0,67
20	0,67	0	0,67	0,67	0,33	1
21	1	0	0,67	1	0,33	1
22	0	0	1	1	0,67	1

Data matrix on the outcome exploitation readiness and characteristics (self-assessment).

Nr.	EX	T	F	P	R	M
1	0,67	0,33	0,67	0,33	0,33	0,33
2	0,33	0	1	1	0,67	1
3	0,67	0,33	0,33	0,33	0,67	0,33
4		0	1	0,67	0,67	0,67
5	0,67	0	0,67	0,67	0,67	0,67
6	1	0	0,67	0,67	0,67	1
7	0	1	0,33	0,67	0,33	0,33
8	0,67	0	0,67	0,67	0,67	0,67
9	0,67	0,67	0,67	0,67	0,67	0,67
10	0,67	0	0,67	0,67	0,67	0,67
11	0,33	0,67	1	1	1	1
12	0	0,33	1	1	0,67	1
13	0	0	0,67	0,67	0,33	0,67
14	0,67	0	0,67	0,67	1	1
15	0,67	0	0,67	0,67	0,67	1
16	1	0	0,67	0,67	0,33	1
17	0,33	0,33	0,67	0,67	0,67	0,33
18	0	0	0,67	1	0,33	0,33
19	0,33	0,33	1	0,67	0	0,67
20	0,67	0	0,67	0,67	0,33	1
21	1	0	0,67	0,67	0,33	0,67
22	0	0	0,67	1	0,67	0,67

Data matrix on the outcome exploitation readiness and characteristics (expert opinion).

Case Number	EX	T	F	P	R	M
1	0,67	0,33	0,67	0,33	0,33	0,33
2	0,33	0	0,67	1	0,67	1
3	0,67	0,33	0,33	0,33	0,67	0,67
4		0	1	0,67	0,67	0,67
5	0,67	0	0,67	1	0,67	0,67
6	1	0	0,67	0,67	0,67	1
7	0	1	0,33	0,67	0,33	0,33
8	0,67	0	0,67	0,67	0,67	0,67
9	0,67	0,67	0,67	0,67	0,67	0,67
10	0,67	0	0,67	0,67	0,67	1
11	0,33	0,67	1	1	1	1
12	0	0,33	0,67	0,67	0,67	0,67
13	0	0	0,67	0,67	0,33	0,67
14	0,67	0	0,67	0,67	1	1
15	0,67	0	0,67	0,67	0,67	1
16	1	0	0,67	0,67	0,33	1
17	0,33	0,33	0,67	0,67	0,67	0,67
18	0	0	0,67	0,67	0,33	0,67
19	0,33	0,33	0,67	0,67	0	0,67
20	0,67	0	0,67	0,67	0,33	1
21	1	0	0,67	1	0,33	1
22	0	0	1	1	0,67	1

ANNEX III: SOLUTIONS

Solution on the outcome product readiness (self-assessment).

--- COMPLEX SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.873275

	raw coverage	unique coverage	consistency
~T*F*P*R	0.698353	0.0254491	0.902321
~T*F*P*M	0.798653	0.101048	0.863269
F*P*R*M	0.723802	0.0508982	0.852734
~T*F*~P*~R*~M	0.297156	0.025449	1
~T*~F*~P*R*~M	0.247754	0.025449	1

solution coverage: 0.925898
solution consistency: 0.840353

--- PARSIMONIOUS SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.873275

	raw coverage	unique coverage	consistency
~P	0.446108	0.0254491	0.947536
R	0.774701	0.0254491	0.838057
M	0.898952	0.150449	0.765944

solution coverage: 0.975299
solution consistency: 0.78024

--- INTERMEDIATE SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.873275

Assumptions:
F (present)
P (present)
R (present)
M (present)

	raw coverage	unique coverage	consistency
~T*R	0.723802	0.0508981	0.878293
~T*F*~P	0.420659	0.025449	1
~T*F*M	0.798653	0.101048	0.863269
F*P*R*M	0.723802	0.0508982	0.852734

solution coverage: 0.925898
solution consistency: 0.821927

Solution on the outcome negated product readiness (self-assessment).

```
--- COMPLEX SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.928726

                              raw       unique
                              coverage  coverage  consistency
                              ----------  ----------  ----------
T*~F*P*~R*~M                  0.230324  0.0775463  1
~T*F*P*~R*~M                  0.497685  0.344907   0.928726

solution coverage: 0.575231
solution consistency: 0.937736

--- PARSIMONIOUS SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.928726

                              raw       unique
                              coverage  coverage  consistency
                              ----------  ----------  ----------
P*~R*~M                       0.575231  0.575231  0.937736

solution coverage: 0.575231
solution consistency: 0.937736

--- INTERMEDIATE SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.928726

Assumptions:
~F (absent)
~P (absent)
~R (absent)
~M (absent)
                              raw       unique
                              coverage  coverage  consistency
                              ----------  ----------  ----------
~F*P*~R*~M                    0.459491  0.0775463  0.923256
~T*P*~R*~M                    0.497685  0.115741   0.928726

solution coverage: 0.575231
solution consistency: 0.937736
```

Solution on the outcome product readiness (expert opinion).

--- COMPLEX SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.837545

	raw coverage	unique coverage	consistency
~T*F*P*M	0.799401	0.0763474	0.819018
F*P*R*M	0.749251	0.0508982	0.857021
~T*F*~P*~R*~M	0.247754	0.025449	0.909341
~T*~F*~P*R*M	0.346557	0.025449	0.933468

solution coverage: 0.901198
solution consistency: 0.799469

--- PARSIMONIOUS SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.837545

	raw coverage	unique coverage	consistency
~T	0.924401	0.0501497	0.68573
M	0.92515	0.0508983	0.711982

solution coverage: 0.975299
solution consistency: 0.673385

--- INTERMEDIATE SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.837545

Assumptions:
F (present)
P (present)
R (present)
M (present)

	raw coverage	unique coverage	consistency
~T*F	0.82485	0.126497	0.803793
~T*R*M	0.723802	0.025449	0.878293
F*P*R*M	0.749251	0.0508982	0.857021

solution coverage: 0.901198
solution consistency: 0.765903

Solution on the outcome negated product readiness (expert opinion).

```
--- COMPLEX SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.815934

                              raw       unique
                              coverage  coverage  consistency
                              ----------  ----------  ----------
~T*F*~P*~R*~M                 0.34375     0.152778    0.815934
T*~F*P*~R*~M                  0.268519    0.0775463   0.875472

solution coverage: 0.421296
solution consistency: 0.844548

--- PARSIMONIOUS SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.815934

                              raw       unique
                              coverage  coverage  consistency
                              ----------  ----------  ----------
~M                            0.421296    0.421296    0.784483

solution coverage: 0.421296
solution consistency: 0.784483

--- INTERMEDIATE SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.815934

Assumptions:
~F (absent)
~P (absent)
~R (absent)
~M (absent)
                              raw       unique
                              coverage  coverage  consistency
                              ----------  ----------  ----------
~T*~P*~R*~M                   0.34375     0.152778    0.815934
T*~F*~R*~M                    0.268519    0.0775463   0.875472

solution coverage: 0.421296
solution consistency: 0.844548
```

Solution on the outcome exploitation readiness (self-assessment).

--- COMPLEX SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.900302

	raw coverage	unique coverage	consistency
~T*F*~P*~R*~M	0.319807	0.0647343	0.909341
~T*~F*~P*R*~M	0.287923	0.0328502	0.900302

solution coverage: 0.352657
solution consistency: 0.917085

--- PARSIMONIOUS SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.900302

	raw coverage	unique coverage	consistency
~P	0.512077	0.512077	0.889262

solution coverage: 0.512077
solution consistency: 0.889262

--- INTERMEDIATE SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.900302

Assumptions:
F (present)
P (present)
R (present)
M (present)

	raw coverage	unique coverage	consistency
~T*F*~P	0.479227	0.0647343	0.937618
~T*~P*R	0.447343	0.0328503	0.933468

solution coverage: 0.512077
solution consistency: 0.941385

Solution on the outcome negated exploitation readiness (self-assessment).

--- COMPLEX SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.886288

	raw coverage	unique coverage	consistency
~T*F*P*~M	0.404695	0.280751	0.928879
T*~F*P*~R*~M	0.186854	0.0319249	1
T*F*P*R*M	0.248826	0.0938967	0.886288

solution coverage: 0.561502
solution consistency: 0.899248

--- PARSIMONIOUS SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.886288

	raw coverage	unique coverage	consistency
T	0.342723	0.124883	0.914787
P*~M	0.467606	0.249765	0.937853

solution coverage: 0.592488
solution consistency: 0.904011

--- INTERMEDIATE SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.886288

Assumptions:
~F (absent)
~P (absent)
~R (absent)
~M (absent)

	raw coverage	unique coverage	consistency
T	0.342723	0.124883	0.914787
P*~M	0.467606	0.249765	0.937853

solution coverage: 0.592488
solution consistency: 0.904011

Solution on the outcome exploitation readiness (expert opinion).

```
--- COMPLEX SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.800403

                              raw      unique
                              coverage   coverage   consistency
                              ---------- ---------- ----------
~T*~F*~P*R*M                  0.383575   0.383575   0.800403


solution coverage: 0.383575
solution consistency: 0.800403

--- PARSIMONIOUS SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.800403

                              raw      unique
                              coverage   coverage   consistency
                              ---------- ---------- ----------
~T*~F                         0.511111   0.511111   0.842357

solution coverage: 0.511111
solution consistency: 0.842357

--- INTERMEDIATE SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.800403

Assumptions:
F (present)
P (present)
R (present)
M (present)
                              raw      unique
                              coverage   coverage   consistency
                              ---------- ---------- ----------
~T*~F*R*M                     0.479227   0.479227   0.833613

solution coverage: 0.479227
solution consistency: 0.833613
```

Solution on the outcome negated exploitation readiness (expert opinion).

```
--- COMPLEX SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.886288

                              raw       unique
                              coverage  coverage  consistency
                              --------  --------  ----------
~T*F*~P*~R*~M                 0.278873  0.0929577 0.897281
T*~F*P*~R*~M                  0.248826  0.0319249 1
T*F*P*R*M                     0.248826  0.0629108 0.886288

solution coverage: 0.404695
solution consistency: 0.863727

--- PARSIMONIOUS SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.886288

                              raw       unique
                              coverage  coverage  consistency
                              --------  --------  ----------
T                             0.342723  0.0938967 0.914787
~M                            0.37277   0.123944  0.921114

solution coverage: 0.466667
solution consistency: 0.879646

--- INTERMEDIATE SOLUTION ---

frequency cutoff: 1
consistency cutoff: 0.886288

Assumptions:
~F (absent)
~P (absent)
~R (absent)
~M (absent)
                              raw       unique
                              coverage  coverage  consistency
                              --------  --------  ----------
T                             0.342723  0.125822  0.914787
~P*~R*~M                      0.309859  0.0929577 0.906593

solution coverage: 0.435681
solution consistency: 0.87218
```