Tracing the mechanisms of science-industry knowledge transfer

A critical realist study within a food research institute

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ABSTRACT

The compelling challenges facing the food industry call for imminent action. Nutrition, obesity, food safety, and food and health are examples of unprecedented pressures that a single organisation is not in a position to address alone. In recognising the growing concern to address these challenges, this study has focused on the transference of knowledge from the Institute of Food Research (IFR) to food manufacturer SMEs in the UK. This study investigates three knowledge transfer projects within IFR by identifying the mechanisms driving them.

The study is positioned in the science-industry knowledge transfer literature. An analysis of this literature leads to the conclusion that current studies rely heavily on correlations with positivist assumptions, with a deficit of explanatory accounts. There is also a lack of studies that look at knowledge transfer at different levels of analysis. The aim of this study is to offer a mechanismic explanation for how and why knowledge transfer happened in these three projects. From empirical data from 52 interviews with individuals involved in the projects, observations from industry and science events, and document analysis, a novel process-tracing methodology was employed to trace the generative mechanisms for each project.

The data are analysed from a critical realist perspective. An explanatory account is provided through the incorporation of a multilevel framework that includes structure, agency and interaction levels. Through qualitative analysis, abductive reasoning and systematic combining, the findings move from what happened, to the mechanisms underlying each project, to a contextualised theoretical explanation.

Because this study problematises conventional research approaches, it is able to shed new light on the phenomenon under study: the generative mechanism that explain science-industry knowledge transfer. Methodologically, it offers a critical realist framework for the analysis of different ontological layers, and also a process-tracing approach that looks at analytically investigating empirical evidence. The practical contribution is a robust explanation that recognises the micro-foundations and structural constraints and opportunities in knowledge transfer relationships. The conclusion is that although there is no single ideal type of project, motivations or interactions that makes knowledge transfer successful, the predominant mechanisms tend to be rooted in social interactions and non-pecuniary rewards.

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I have been incredibly fortunate to have a husband who has strived to understand my Ph.D. experience and I know how crucial he has been to me completing it. Despite the fact that he has also been pursuing new changes himself, his ability to adapt and tolerance to understand my ramblings, as well as practical, financial and moral reassurances, were fundamental to finish this process. Thank you James, for your support, encouragement and love.

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1 INTRODUCTION

This thesis begins with a problem. The problem is that there are many societal challenges in the food industry which are too intricate to be undertaken by a single organisation. Some issues faced in the current landscape are: obesity, food safety, nutrition and health, authenticity, farm-to-fork logistics, foodborne diseases, healthy ageing, food waste, food security, and environmental welfare. Also, there is increasing consumer awareness of the link between diet and health and concerns over food safety. Thus, the relationship between food, nutrition, safety and health are amongst the most critical issues of our time. These challenges are large, highly complex and involve multiple stakeholders. Instead of looking for gaps within the literature, this study began with practical observations and discussions with these stakeholders in the food industry in the UK.

Participation in conferences and seminars as well as interviews with food retailers, researchers, scientists, government officials and food manufacturers brought to the fore that a great deal of work that looks into tackling these societal challenges is predominantly located in academic and research institute environments, and sometimes within large food manufacturers. However, the food industry in the UK is composed of nearly 6,000 SMEs, which are not always able to access the latest innovation and technology. A recognition of where this kind of research is undertaken led to the motivation for investigating the Institute of Food Research (IFR), to understand how their science is disseminated to industry and consequently to consumers. Thus, specific projects within IFR were selected and a process of investigating how knowledge is transferred began.

The process of problematisation typically starts with the identification of practical frustrations. It also challenges underlying assumptions from existing theories, as an alternative to the gap-spotting approach which “seems to assume that we know what the boundaries of a field look like” and “tends to dissuade examination of new areas” (Clark and Wright, 2009, p.6). On the contrary, problematisation argues that “the route to good theory leads not through gaps in the literature, but through an engagement with problems in the world” (Kilduff, 2006, p. 252) and leads researchers “to formulate research questions that may facilitate the development of more interesting and influential theories” (Alvesson and Sandberg, 2011, p. 267).

A further motivation of this study is to propose the adoption of a different perspective on knowledge transfer, one that stresses generative mechanisms to create a mechanismic explanation. Mechanisms are analytical constructs that draw connections between social instances by showing how a cause produce an effect. The vast body of literature that

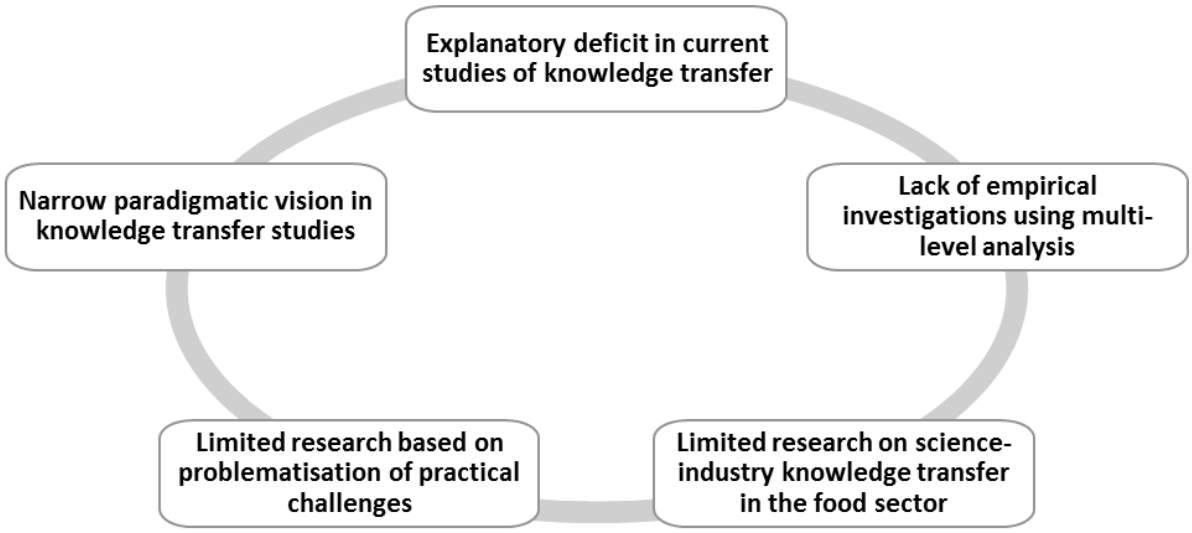
investigates knowledge transfer, by and large, has not been able to fully address the problems of causation and explanation. The argument of this study is that the knowledge transfer literature suffers from a lack of theory of action and a poor integration of levels of explanation. It argues that to explain knowledge transfer is to explain why individuals are motivated, understand their beliefs, how they interact and how they respond to different structural constraints and opportunities. By opening up the black box and exposing the generative mechanisms for knowledge transfer, it is possible to produce a robust explanation that can significantly enhance the theoretical development of this discipline and produce suggestions which can ultimately improve the process of knowledge transfer. In summary, in this thesis, it is argued that:

- There is a problematisation which involves food sector challenges that are greater than an individual company can tackle, therefore the need to exchange and transfer knowledge is paramount.
- The focus on science-industry knowledge transfer is important because most scientific research aims at solving some of the sector's challenges.
- Government and policy shifts to measure impact, such as within the Research Excellence Framework (REF), encourage collaboration between science and industry. IFR and other institutes now have to identify and follow 'pathways to impact'.
- A mechanismic explanation is lacking in the knowledge transfer literature. Causal mechanisms can help researchers overcome the 'black box' problem that arises in causal inference that establishes associations between variables.
- A mechanismic approach can improve empirical studies and deepens subsumption by providing ontological depth, creative thinking and more precise explanations.
- Mechanisms are unobservable, and therefore their description is bound to contain concepts that do not occur in empirical data.
- Mechanismic explanations are growing in the social sciences but are still scant in management studies. This is an opportunity to offer a robust framework and methodological approach to develop this kind of study in other management disciplines.

1.1 Limitation of Existing Research

In the existing research on knowledge transfer there are a few limitations and challenges that underline the motivation for this research and emphasise its relevance, as summarised in Figure 1. These limitations and challenges provide an understanding of the rationale for a more in-depth investigation as well as allows the framing of the problem area of this study.

Figure 1: Overview on limitations and challenges of existing research



Explanatory deficit in current studies of knowledge transfer. Despite the process-orientated nature of knowledge transfer, prior studies have generally operationalised it as a single dependent variable associated with a range of possible antecedents rather than delving into unfolding the underlying mechanisms between the transferor and the recipient. This study argues that there is an explanatory deficit which is common in regularity or covariational analysis. It also argues that macro explanations are incomplete, which implies a neglect of micro-foundations. Previous studies can tell whether some condition qualifies as a cause of an outcome, but does not explain how this cause produces the outcome.

One of the fallacies of previous studies is their cognitive shortcut. A statistical association between knowledge transfer and trust, for example, tells us that individuals and organisations must achieve a certain level of trust between each other so that knowledge can be transferred or exchanged. This kind of explanation is a shortcut for a much more complex process that is likely to be rooted in individual's motivations and beliefs. Thus, these relationships say nothing about why this is the case. To answer such questions, it is necessary to introduce and explicate the generative mechanisms that might have produced the observed relationship of trust. While previous studies often discover that a heterogeneous group of independent variables are statistically associated with knowledge transfer, they lack tools for understanding why such diverse factors are related to the phenomenon, resulting in an absence of theoretical integration.

Lack of empirical investigations using multi-level analysis. Many studies in the knowledge transfer discipline are placed on a level of analysis that is above that of the individual. In fact, the explanandum (i.e. the dependent variables) are usually placed at the level of the firm.

However, the explanans (i.e. the independent variables and the mechanisms that link them to the dependent variables) may involve other levels of analysis as well, such as the industry level, or the level of individuals. In social sciences, the aim usually is to explain either a macro-level phenomenon such as a firm-level outcome, or a link between macro phenomena. An example of the latter may be an observed correlation between network range and knowledge transfer to improve the performance of firms (Reagans and McEvily, 2003). Therefore, this study argues that instead of analysing relationships exclusively on the macro level, it is important to establish how macro level conditions affect individuals, how individuals assimilate the impact of these conditions, and how a number of individuals through their actions and interactions generate outcomes.

Limited research on science-industry knowledge transfer in the food sector. Although previous studies have looked into science-industry knowledge transfer relationships, there are scant studies that particularly observe the food sector. Being an important sector both from economic and societal perspectives, there is a real need for investigations in this area. The vast body of literature in knowledge transfer may suggest food practices but they are typically from the industry's perspective, focused on large organisations and statistical findings. There is hardly any empirical evidence on how scientific knowledge is transferred to SMEs.

Limited research based on problematisation of practical challenges. The current mainstream body of literature in knowledge transfer and management studies in general, use a gap-spotting approach as the prevalent way of generating research questions. Common ways of gap-spotting range from investigation into competing explanations, overlooked disciplines, under-researched areas, lack of empirical support, extending and complementing existing literature and so on. A criticism of gap-spotting routes is that it tends to offer the same views on phenomena, without much questioning of alternatives and a lot of the time with shallow relevance to practice. Problematisation (Alvesson and Sandberg, 2011) is an alternative to gap-spotting as a way of generating research questions to illuminate and question prevalent assumptions. These assumptions can be related to the discipline, paradigm, ideology or practical issues (Sandberg and Alvesson, 2011). This study follows a problematisation approach to the research question, by starting with a practical exploration and questioning of current issues in the food industry.

Narrow paradigmatic vision in knowledge transfer studies. The current discourse in knowledge transfer literatures is heavily based in positivist assumptions, and so far, little effort has been taken to understand alternative philosophical and paradigmatic views. As Astley (1985, pg.504) pointed out "mediocre scientists are those who are unable to see beyond

established paradigms because of their failure to grasp and articulate their colleagues' ground assumptions". He suggests that interesting theories and successful researchers are ready to question and are open to create opportunities to critically investigate what is taken for granted. This study favours this view and looks with an alternative philosophical lens to investigate a phenomenon, with a different interpretation of reality to produce more robust theoretical integration.

1.2 Positioning within the wider field of knowledge

To overcome the limitations from existing research, this study addresses causality from a mechanismic perspective, by investigating three science-industry knowledge transfer projects. There are a few limitations to this study: it is limited to a single setting, IFR, and a single country, the UK. It looks at science-industry knowledge transfer in the food industry from IFR and scientists' perspectives and not from that of food manufacturer SMEs.

This study is clearly positioned within the knowledge transfer literature, particularly in science-industry knowledge transfer, and also within mechanismic explanatory studies. Results may significantly enhance existing literature on knowledge transfer, and the theoretical contribution is expected to develop a theoretical conceptualisation of the mechanisms for this phenomenon. Whereas the empirical literature on knowledge transfer has to a large extent limited itself to a single level of analysis, this research intention is to further explore this phenomenon from an integrated framework with different levels of analysis. A methodological contribution will be a novel analytical framework, and a process-tracing approach. This study is also expected to offer practical contributions by offering a more robust explanation for why and how knowledge transfer happens, which will influence managerial decision-making and, potentially, policy-making.

1.3 Research Question and Objectives

The practical problem behind this study is that knowledge that tackles wider societal challenges in the food industry is predominantly located in academia, research institutes and large food manufacturers. On the basis of this assertion and considering that the majority of food manufacturers in the UK are SMEs, an investigation into knowledge transfer from academia to industry is the driving motivation for this research. From a research perspective, this study aims to understand how and why knowledge is transferred from a research institute, IFR, to food manufacturer SMEs. Thus, the resulting central research question driving this research is:

How and why knowledge is transferred between a publicly funded food research institute and food manufacturer SMEs in the UK?

This central question guides this study, reflecting the philosophical lenses, methodological choices, analyses and discussions. Based on this question, two main objectives arise:

Objective 1: To reveal the generative mechanisms that are driving knowledge transfer between IFR and industry to address this sector's challenges.

Objective 2: To develop a contextualised explanation of how and why knowledge transfer takes place.

1.4 Research Methodology: an explanatory process

This research aims to contribute to the understanding of the generative mechanisms that enabled knowledge transfer from IFR, a publicly funded food research institute, to food manufacturer SMEs, by analysing three projects of knowledge transfer within IFR. Rather than offering a detailed deep description (Stake, 1995), it will offer a mechanismic explanation (Hedstrom and Ylikoski, 2010) with a critical realist lens (Bhaskar, 1998) of the underlying mechanisms that enabled knowledge transfer. The quality of the contribution of a mechanismic explanatory study does not rely in the number of cases being studied, but in the new insights revealed by an in-depth analytical account of each case. Therefore, these cases were selected because of the likelihood that they will reveal new insights about different knowledge transfer processes that had different drivers.

To achieve this, it is using process-tracing as the primary research design, which involved the collection of evidence from interviews, documents and observations. Process-tracing is a within-case method of analysis and it is a popular method in political sciences (Collier, 2011), but still very novel to the discipline of knowledge transfer. It was chosen because it is a robust design to analytically investigate generative mechanisms. The aim with this approach is not to identify law-like patterns or correlations, but to identify the underlying mechanisms that drive knowledge transfer in specific cases. The type of evidence collected for this study depends largely on the ability of the evidence to contribute to the search for a causal mechanism at each analytical level which includes the quality of the data regarding its suitability (how suitable is the data to evaluate the presence of a mechanism), content (what do the data tell us about the presence of a mechanism) and accuracy (how reliable the data are in terms of researcher's inefficiency and biases and in terms of respondents' biases). Therefore, different sources of evidence were used: interviewees, contracts, documents, journal articles, websites, magazine

articles and others. Each piece of evidence was assessed separately for accuracy and analysis was done using abductive reasoning.

This research is positioned as a critical realist study because the philosophical underpinnings and assumptions come from critical realist philosophy, where the world is seen from a stratified ontology where generative mechanisms are unveiled to form a plausible explanation of a phenomenon. The general axiology of a critical realist study is emancipatory, in the sense of shedding new light on a phenomenon in order to root out new possibilities. In this case, the aim is to unmask the mechanisms enabling knowledge transfer in a particular setting. The role of theory is decisive for research studies and methods must take ontological and epistemological dimensions into account. By viewing society as an open system and analysing mechanisms in deeper ontological layers, it is possible to conduct discussions on the potential consequences of these mechanisms working in a different setting.

It is also a process-tracing study because it uses a process-tracing design to collect evidence that will help to create the narrative examples which will form the conceptualised mechanisms. Process-tracing is well placed to move theory beyond unproductive either/or debates to empirical applications in which both agents and structures matter as well as are explained and understood through critical realist ontological and epistemological lenses. It moves us away from correlational arguments and as-if styles of reasoning toward theories that capture and explain the world as it really works. Process-tracing also offers the ability to make connections between different theoretical tool kits. For example, neoclassical economists, obsessed by price competition, failed to grasp the central mechanism of the capitalist economy, namely, innovation. By contrast, Schumpeter (1942, pg.83) exhibited this mechanism in a single statement: “what sets and keeps the capitalist engine in motion” is nearly incessant “creative destruction”.

1.5 Researcher Reflexivity

My own assumptions and preconceptions played a part during the research process, therefore it is important to offer a reflexive account on how the process unfolded. My journey began with my search for a problem and a case worth pursuing. Coming from an early upbringing in an agricultural environment and my passion for food enticed me to start my research in the food industry in the UK, trying to understand how the entire chain operates, from farm to fork. It soon became prevalent that key challenges within this industry are related to larger societal issues such as health, waste and safety. It also became apparent that a lot of the innovation that tackles these challenges came from science based at universities and research institutes.

I became an active participant in conferences and seminars in the food industry to ensure I understood their frustrations and challenges. I also took on an initial study with key figures in the food industry – food retailers, government bodies and food scientists. After this exploration was completed, I was able to refine my research question and identify the Institute of Food Research (IFR) as a suitable research site. IFR is considered one of the leading food research institutes in the world and their work is recognised internationally. Their science and projects are focused on issues related to food and health, food safety and food waste. It was selected as the main site for this study for the following reasons: (1) it is a world leader in food research that tackles larger societal concerns; (2) they have projects and links to the food industry and governmental bodies (3) the site was close to the university and so access to the people there was straightforward and cost effective from the researcher's perspective. Once the research was agreed to be focused on IFR, an academic co-supervisor from IFR was identified and invited to join the supervisory team, which enabled greater access to projects and information for the research.

Having IFR on my doorstep and becoming involved in constructing a bid for a Knowledge and Innovation Community in Food (Food KIC) with them, brought me closer to the institute, as well as having the opportunity to have my co-supervisor there at the start of my study. It quickly came to surface that the array of projects the institute does are tightly related to my areas of interest, however, the innovative processes created there did not seem to be directly transferred or shared with the rest of the food industry. My quest to understand how and why knowledge created within the institute is transferred to industry began. Another burning issue that I wanted to understand was my own assumptions about the world and how my philosophical worldview would affect my pursuit. By delving into different philosophies and theories, I found myself immersed into understanding different angles.

My academic background in my masters' degree in Supply Chain Management and bachelor's in International Trade have strong positivist foundations. This school of thought influenced me a great deal for my initial research proposal. When I started the PhD it was the first moment where I could reflect upon these foundations and position my own worldview of social reality. The more I understood their meaning, the more critical realism felt right. For me as a researcher, critical realism offers an understanding of reality that is both real and practical, fitting well the purpose of the study which is explanatory. It also fits in the way that it challenges conceptualisations of the phenomenon under study, searching for underlying mechanisms that are not directly observable. Therefore, matching the research question with my philosophical view of the world was the beginning of a personal journey of discovery. Primarily, I immersed

myself in four main literatures: the philosophy of sciences, food & health challenges, innovation, and knowledge transfer.

I started with an initial study and very exploratory questions, interviewing researchers at IFR and talking about their projects. I also interviewed food retailers, government organisations and research funders to understand where their motivations come from. Participating in several food conferences, seminars and workshops gave me an opportunity to observe how academia and industry behave, what is important to them and what makes them tick. I kept notes about these observations and they helped me adjust questions, and confirm or disconfirm previous thoughts. During the initial study, I asked very broad questions, trying to get as much information as possible about their motivations, their concerns, what kind of projects they do and how they view the current context. In the end, I chose to investigate three projects within IFR, all of which have involvement with the food industry, with implications and applications for food manufacturers SMEs. There is criticism that a small number of cases is not suitable for generalisable findings. This criticism is related to a positivist philosophy and the pursuit of predictive general laws. However, when the purpose of a study is to build a causal explanation, contextualised single or a few cases is preferable.

Having co-supervision from an important senior figure from IFR opened many doors for me, and I believe not having that point of contact would have made my engagement more difficult, but not impossible. Also, having a topic that felt “right” for them was incredibly important. Although innovation and knowledge transfer are well-studied subjects, the participants were very willing to share their thoughts and talk about their projects, and what they thought was good and what could be improved.

From contacting them by email for the first time, to arranging a face-to-face interview, interviewing them and following it up with a thank you email, I always tried to be as honest and open as possible, and explain what my research was about. However, the subject itself evolved as the interviews went on. I perceived researchers at IFR to be very close to each other, which could be due to the fact that they share laboratory space and sometimes they share scientists and PhD students. They were also very open to my questions, in the sense that they had no barriers to share their experiences and contacts, which proved to very helpful with my snowballing technique.

During the interviews I aimed to have some previous knowledge about their projects, however, the level of detail given during the interviews was better than I expected. Before going to the interviews I was conscious that I am not a scientist and my technical knowledge is very limiting,

therefore I feared being treated as less equal, working to my disadvantage. To my surprise, the fact that I came from a Business School with a business background was the disadvantage, giving the interviewees the impression that I was an expert and would judge how they manage their projects. Questions such as “how are we doing?” and “do you think we are managing ok?” made me feel uncomfortable at the same time as making me realise that I needed to be humbler than I thought I should. To build rapport, I would start by putting them at peace with relation to the confidentiality, that I was not interested in confidential findings, that I was interested in the process and that I was interested in learning how they do their projects and was not there to make judgements. This approach worked favourably and it was possible to tell that they opened up quite detailed and personal accounts of their experiences.

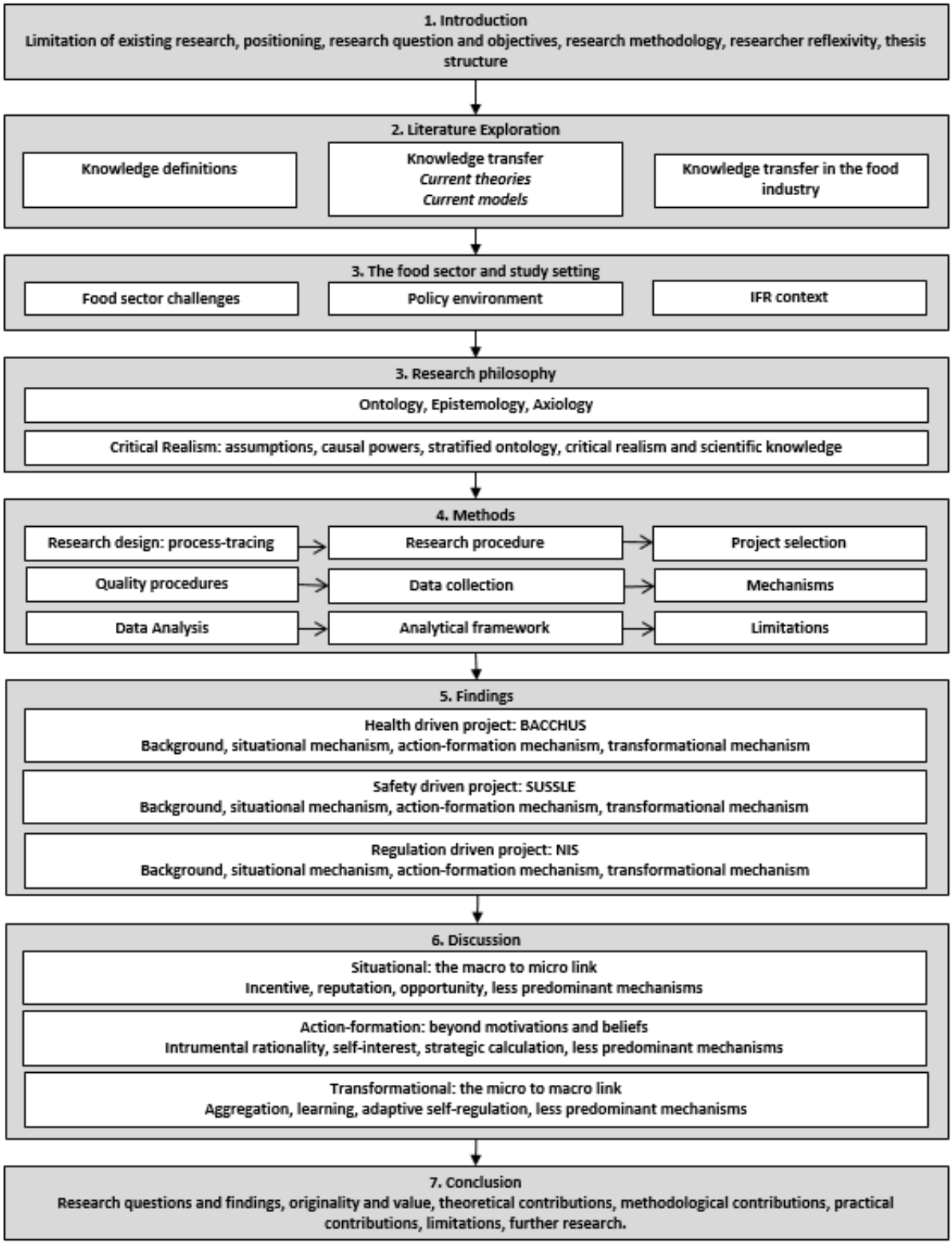
In the first few interviews I would dress quite smartly as I would for a business meeting but I soon realised that evoked a perception of authority which I did not want. So I started to dress more casually like most of the interviewees. It is difficult to tell if that made a difference or the fact that I was around and seeing them more often that made them feel more comfortable with my presence. Consciously or not I adapted to their environment and it worked in the sense of creating rapport. Having an access card to IFR’s main building meant that I didn’t have to sign in as a visitor and could just be “one of them”. I also had accessibility to meeting rooms and could book them freely. This was helpful when I interviewed people from other parts of the Norwich Research Park and they preferred to come to me for a face-to-face interview. Because they previously worked with IFR but not Norwich Business School, they felt comfortable meeting at IFR.

The decision to exit fieldwork occurred when I felt I had sufficient data to construct a narrative and consequently abstract the mechanisms I needed. This was the beginning of my theorising process and it was not easy because I developed strong engagement with some of the interviewees. The result from interacting with participants created an empathy towards their stories and projects. Thankfully I was not over-embedded in the relationships and I was able to distance myself from the field. I also developed a consciousness regarding how I felt which helped in collecting data in a more objective form. Exiting fieldwork also prompted reflection, learning and the beginning of a creative process to understand myself as a researcher and also the meaning and implications of my study. High quality theorising is not only an outcome of high-quality, sustained relationships in the field but also an elevated self-consciousness of my contribution to improve the current research.

1.6 THESIS STRUCTURE

The following thesis structure in Figure 2 reflects the major research activities undertaken during this study. The following section explains the purpose of each chapter.

Figure 2: Thesis Structure



Chapter 1: Introduction

The Introduction sets the motivation behind this study, together with an understanding of existing limitations in the literature. This chapter also has the purpose to position this study within the wider field of knowledge and to introduce the main research question and objectives. Research methodology is then considered before an account is provided of the researcher's reflexivity.

Chapter 2: Literature exploration

The purpose of this chapter is to provide a critical review of this study's wider literature and to establish any gaps in the literature around knowledge transfer. It also provides an overview of studies of knowledge transfer in the food sector. The key point is that literature in knowledge transfer is predominantly focused on statistical explanations with a single level of analysis and narrow theoretical integration. There is also a lack of problematising argumentations which leads to the multi-level analytical framework proposed in this study.

Chapter 3: The food sector and study setting

This chapter offers an overview of the current context in the food sector, with a critical discussion on wider societal challenges and how the policy environment influences science-industry knowledge transfer relationships. It also provides an overview of the Institute of Food Research (IFR) and an explanation for choosing this institute as this study's setting. The main points are that there are societal challenges in this sector that are too complex to be tackled by a single organisation, and show how the current policy environment such as the impact agenda influence industrial engagement.

Chapter 4: Research Philosophy

This chapter presents a justification for the philosophical underpinnings of this study. Critical realism is described and an explanation of its assumptions and ontological stratification is offered. It is also a gateway to the next Methods chapter as it reveals how a critical realist study fits into the chosen methodological approach.

Chapter 5: Methods: opening up the black box

The methodological approach of process-tracing is introduced and an explanation into how a mechanismic study that looks into generative mechanisms is offered. The key points are to explain the meaning of mechanisms and how the research methods helped towards capturing the mechanisms. This chapter also introduces the analytical framework used and an

explanation into its various elements and levels. It also described how data was collected and analysed, and how the methods chosen fit into the research design and the analytical framework.

Chapter 6: Findings and analysis

This chapters takes the empirical data and matches with the analytical framework to begin the formation of an explanation for each project. The purpose is to reveal the generative mechanisms for each project. Data is first categorised into the macro codes and an explanation is developed from these data. Through an iterative process of abductive reasoning, each explanation reveals a predominant and less predominant mechanisms for each level of analysis for each project.

Chapter 7: Discussion

In this chapter there is a move from the analysis of the findings, where the mechanisms are revealed, to a critical discussion into how these mechanisms appear or not in the current literature. The purpose is to position the findings from this study within the wider body of literature and to offer a theoretical explanation. By unpacking the meaning of the mechanisms, theorising begins by offering macro and micro theories that help explain each mechanism. The final purpose is to offer a brief description of the implications of these findings.

Chapter 8: Conclusion

This chapter discusses the key contributions of this study, and presents an overview of the final conclusions. It outlines how the main question and objectives are met, the limitations of the study, and directions for future research.

2 LITERATURE EXPLORATION

2.1 INTRODUCTION

The plethora of theories, constructs and approaches to knowledge transfer can generate controversial and unclear explanations. Because this research sets out to discover the generative mechanisms as to why knowledge is transferred, defining this literature is critically important. This chapter reviews the literature on knowledge transfer concepts, models, and theoretical angles. It demonstrates how knowledge transfer has been studied by identifying prominent studies and trends in research. The purpose of this chapter is:

- To define knowledge and knowledge transfer, focusing on theoretical approaches and historical developments;
- To develop an understanding of knowledge transfer that allows for theoretical development;
- To outline and provide an understanding of the relevant knowledge transfer literature in the food industry relating to academic engagement with industry.

To get to such an understanding, firstly a summary of knowledge definitions is offered. Secondly, a review is offered of some of the theoretical angles that have been used in earlier attempts to unravel this complex body of literature. Thirdly, a review of knowledge transfer models together with a critique as to why these perspectives and models have not been able to provide an explanation of why knowledge transfer happens. Lastly, there is an overview of knowledge transfer studies in the food industry.

2.2 KNOWLEDGE DEFINITIONS

What exactly is knowledge? It is neither data nor information, although it is related to both in a matter of degree. The dictionary definition for data (Stevenson, 2010) is “known or assumed facts or things, making the basis of reasoning or calculation”. It assumes that data does not have meaning in itself and can exist in usable or unusable forms. Information can be defined as interpreted data or data that has been given meaning by way of relational connection (Liebenau and Backhouse, 1990). It assumes that there is a sender and a receiver however the meaning or relevance of the information can be useful or not. Knowledge, in a practical sense, can be explained as “actionable information”, which allows for better decision-making. However, knowledge is much broader and deeper than this simplistic notion and involves individual’s perceptions and assumptions of reality, as well as their experiences. These

perceptions and assumptions will, for example, determine the interpretation of the same data and information.

A prominent view of knowledge credited to Plato relates to its tripartite definition as "justified true belief" (Zalta, 2016). This definition helps in thinking how knowledge means different things to different individuals, situations, contexts and cultures. However, they are three words with complex meaning themselves. What is *true* and what is *belief*? Is *justified* something necessarily related to validity or merely a function of a social or cultural basis? In the context of this study, knowledge can be seen as *justified* by science and scientific experiments. Each project investigated here has its own method and evidence which are the results of practical research work. Knowledge is *true* for the participants of each project, both scientists and industrial partners. It can also be assumed that the participants hold a *belief* that the knowledge they are transferring has a significant impact both to the scientists' own research and the applicability of this knowledge in the industrial domain.

There are many definitions, approaches and characteristics associated with knowledge. Philosophical interpretations, such as those offered by Karl Popper (1978), consider three distinct worlds where knowledge exists; the physical universe (World 1), the subjective world (World 2), and artefacts of the first and second worlds (World 3). These worlds interact, meaning that physical and mental states can co-exist. World 3 is the products of thoughts, and can include theories, stories, and social institutions. Edmund Husserl (1970) approached knowledge from a phenomenological angle, where it is determined that an individual's interpretation depends upon the event experienced, and the individual's prior experiences.

Knowledge can also be considered from a psychological viewpoint following, for example, Jean Piaget's (Piaget, 1977) stages of cognitive development. Knowledge has to be personal, relevant, and meaningful, with adults having passed through the four stages of cognitive development to reach a point where they no longer have any developmental stages, but instead they develop increasingly complex schema based on the additional knowledge they gain. Part of Piaget's cognitive development model includes two complementary processes of adaptation called accommodation and assimilation. An individual gains knowledge from the outside world, and they are either able to internalise it without changing it, so assimilate it, or, because the new knowledge does not fit into their prescribed understanding they have to accommodate it by adapting to the changes. Therefore, knowledge proceeds neither from experience with external objects nor from intuitive or logical internal processes, but it develops from a series of cognitive structures, built one above the other, requiring continuous adjustment and leading to further constructions.

These approaches to knowledge highlight that knowledge is concerned with human decision making and cognition. Acquiring knowledge means individuals have to reason and ask questions, and perceive how they will use the knowledge in order to share the gained knowledge. Unlike for data or information, acquiring knowledge is a skilful action that requires us to define, prepare, shape and learn in order to solve a task or a problem (Von Krogh et al., 2000).

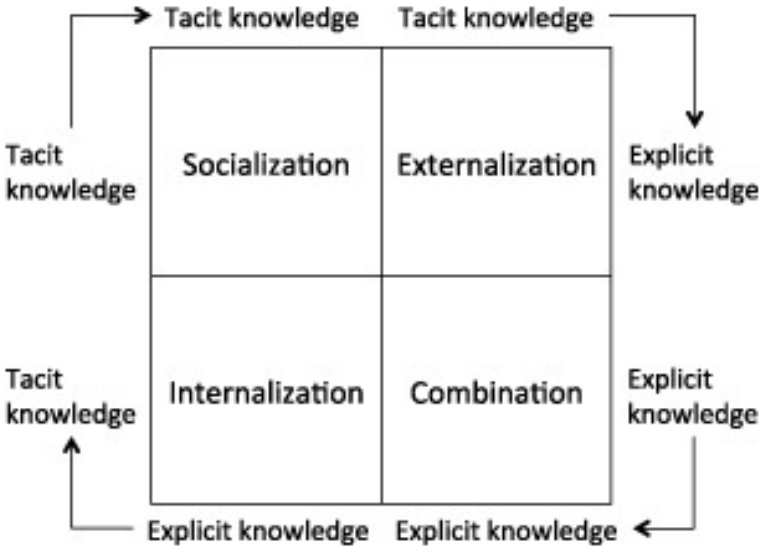
There are also three main schools of thought with regards to how knowledge is theorised. For some knowledge is situated in the mind; for other it is a process; and others regard it as an object (Shin et al., 2001). The diverse viewpoints on knowledge have different implications for knowledge transfer and knowledge management strategies. For example, the viewpoint that knowledge is in the mind would have implications on organisational structure as the knowledge is situated within individuals. A viewpoint that knowledge is a process would have implications on systems and technologies that enable it to be transferred, whilst for knowledge viewed as an object, the focus would be on how to manipulate it to effectively store and retrieve it (Shin et al., 2001).

Davenport and Prusak (1998, pg.5) define knowledge as “a fluid mix of framed experience, values, contextual information, and expert insights providing a framework for evaluating and incorporating new experiences and information”. In an organisational context, this definition assumes that knowledge is embedded within and between individuals and also within organisational routines, norms and process. Nonaka (1994) suggests that knowledge can be explicit or “know-what”, which may be easily codified, copied and stored whereas tacit knowledge or “know-how” tends to have ‘sticky characteristics’ which make it difficult to codify and copy. These sticky characteristics provide valuable barriers to imitation but can create barriers to knowledge transfer and organisation learning. These definitions and the studies that use them tend to be closely related to knowledge intra- and interfirm and less so regarding scientific or academic knowledge transfer. However, the relevance of Nonaka’s work to this research, particularly in terms of know-how is a major part within the projects investigated.

Figure 3 below represents the relationship between tacit and explicit knowledge creation or conversion, according to Nonaka and Takeuchi (1995). As shown in Figure 3, the modes of knowledge transfer can take four forms: socialisation, externalisation, combination and internalisation. As explained by the authors, socialisation refers to an organisational process through which tacit knowledge held by some individuals is transferred in tacit form to others with whom they interact, for example, through team meetings and discussions. Externalisation refers to the transformation of some tacit knowledge into explicit knowledge, via theories,

concepts, models, analogies, metaphors and so on. Combination refers to the conversion of codified knowledge into new forms of codified knowledge. By combining different bodies of explicit knowledge, new categories of knowledge are obtained. Explicit-explicit conversion can be achieved through different channels of communication within the firm such as email or reports. Internalisation is a process of conversion of explicit knowledge into a tacit form. It reflects a type of learning process through which agents are taught and trained to perform specific tasks.

Figure 3: Four modes of knowledge creation or conversion (Nonaka and Takeuchi, 1995, pp.63-69)



Explicit knowledge tends to have easier communication qualities than tacit knowledge. Within the Institute of Food Research (IFR) context of this study, explicit knowledge typically takes the form of publications, patents or spin-offs, and can be transferred through conferences, talks and debates, consultancy, licensing and so on. The tacit knowledge offers more challenges to communicate as it is acquired by and stored within individuals. In this context, tacit knowledge tends to take the form of research findings from various departments and projects within IFR, and it is typically transferred to industry via collaborative projects or joint research for example.

Other ways to define knowledge include situated, partial and latent knowledge (Boisot, 1998). Situated knowledge refers to knowledge which is specific to a situation and in some respects is a form of tacit knowledge because it often takes the form of language, cultural practices and traditions. Situated knowledge is important to the projects in this research as it is related to scientific knowledge and scientists' learning from their experiences. In the projects, a scientist's situated knowledge had to be translated into meaningful application to the food manufacturers.

Some tacit knowledge is difficult or impossible to make explicit, therefore sometimes the use of tools or other mechanisms are important. Many research institutes use technology transfer offices (TTOs) or similar mechanisms to assist the identification and translation of their knowledge. Partial knowledge refers to the idea that it is not possible to know everything there is to know about a subject. This kind of knowledge is also relevant to science-industry contexts as a lot of research projects do not provide an exhaustive understanding of a subject but are very specific to a particular domain. Latent knowledge refers to knowledge that has yet to be harnessed. This kind of knowledge has a particular importance to scientific knowledge, particularly to blue-sky research where experimentations have no apparent immediate application.

Gibbons et al. (1994) explored the changes in the modes of knowledge production in modern society, particularly in science and technology. Mode 1 is identified as “traditional knowledge” generated within a specific disciplinary, cognitive, and primarily in an academic context. Mode 2, represents knowledge generated outside academic institutions in broader, transdisciplinary social and economic contexts. The process of transition from Mode 1 to Mode 2 due to expansion of the higher education in the last few decades produced a surplus of highly skilled graduates who either found work in private industries and laboratories or have founded their own consultancies and think-tanks. This situation caused a proliferation of multiple sites of knowledge production. Mode 2 has a macro focus and involves transdisciplinary, complex network links. By taking into account social, economic, and political interests this mode is closely related to this study. The context of IFR and the projects within it are dependent on and interlinked with the Biotechnology and Biological Sciences Research Council (BBSRC), industry partners, and the UK policy agenda, and therefore have a direct social accountability to a wider audience.

The definitions and debates aforementioned, highlight that knowledge is a much more complex construct than information or data; it involves human cognition and elements of learning. Furthermore, epistemological debates on the nature and definitions of knowledge show that its complexity and varied perspectives can have different managerial implications. While knowledge theories offer insights into the nature of knowledge, they provide limited explanation in terms of how or why knowledge is shared or transferred. The next section will go further into knowledge transfer definitions, including current topics and debates, drivers, motivations and correlated theories for this vast body of literature.

2.3 KNOWLEDGE TRANSFER

In the traditional 'Mertonian' world of scientific research (Merton, 1957), scientists' priority should be of discovery and recognition, by being first to communicate an advance in knowledge only to the scientific community. However, the changing institutional context has sought to exploit scientific knowledge for economic competitiveness and commercial engagement (Lambert, 2003). Moreover, the knowledge society that we currently experience entices us to work together and to develop closer relationships for the survival and prosperity of organisations. For example, science-industry alliances continue to proliferate because they can be instrumental in helping firms create new knowledge and technologies. Yet, many complexities associated with this kind of relationship, in particular how and why knowledge is transferred, have not been fully studied and understood.

Knowledge creation that comes from knowledge transfer is central for driving innovations in both precompetitive and competitive phases of technological development where both are necessary for determining an organisation's competitive advantage (Gopalakrishnan and Santoro, 2004). Because of this development, the importance of the link between universities and research institutes with industry in modern economies has received much attention lately. Key indicators such as partnering projects, patenting, industrial funding and joint authorship of articles reveal that these are significant for both sides of the relationship. Consequently, research has been published on different channels of knowledge transfer (Agrawal, 2001, Schartinger et al., 2002). These indicators are the practical manifestation of knowledge transfer and can be assessed according to different criteria such as their competence, type of governance, type of interaction, geographical proximity and so on.

Knowledge transfer has been approached from numerous perspectives and levels of analysis. Thus, the literature contains a multiplicity of meanings for this construct. The following sections will provide an overview of knowledge transfer definitions, and current theoretical angles and models that explain or are associated with the knowledge transfer literature. [1]

[1] Other streams of knowledge transfer literature that are not included in this literature exploration but are complementary to this study include open science (see, for example, Grand 2015; academic capitalism (see, for example, Venditti and Ferone 2012, and entrepreneurial universities (see, for example, Kalar and Antoncic 2015).

2.3.1 KNOWLEDGE TRANSFER DEFINITIONS

Knowledge moves between individuals and between organisations either through the processes of transfer, sharing, or of exchange. Wang and Noe (2010) suggested that transfer involves the sharing of knowledge from source to recipient, and the application of this knowledge by the recipient; sharing has the purpose of helping others by encouraging collaboration to develop new ideas and solve problems; exchange is a two-way process of knowledge sharing and knowledge seeking between different individuals.

Knowledge transfer between research institutions and industry is one of the key ways to generate more innovation and increase industry's competitiveness. Some authors have defined knowledge transfer with a focus on intrafirm rather than on transfer between scientists and industry. For example, Argote and Ingram (2000, pg.151) defined knowledge transfer as "the process through which one unit (e.g. group, department, or division) is affected by the experience of another". Some researchers have used the terms "knowledge transfer" and "technology transfer" interchangeably while others contend there are differences. For example, Levinson and Asahi (1995) argued that the creation of new knowledge involves the absorption and understanding of new technologies, whereas Gopalakrishnan and Santoro (2004) make a distinction between knowledge transfer (KT) and technology transfer (TT). They argued that technology refers to new tools, methodologies, processes, and products whereas knowledge embodies broader learning. By examining the role of organisations' structure within university-industry relationships in 21 industries, they concluded that firms with more mechanistic structures such as stable and direction-oriented cultures had more successful knowledge transfer whilst firms with more organic structures such as flexible and change-oriented cultures had more successful technology transfer. The firms' trust in their university research partner was equally important for both activities. Although the view of their study comes from the structure of the industrial partner, it offers an insight for this study in terms of the organisational structure of SMEs in the food industry, the significance of their cultures and how it can affect knowledge transfer projects with research institutes.

Whilst most studies view knowledge transfer at the organisational level, Inkpen and Tsang (2005) explain transfer of knowledge on the individual level using social capital dimensions. They show how knowledge acquired in one situation applies or fails to apply to another situation depending on an individual's network links. Other scholars have defined knowledge transfer as a socially collaborative construct (Bjorkman et al., 2004, Chung-Jen et al., 2014) and focused attention on socialisation mechanisms and agency. Organisational knowledge creation, on the other hand, is defined as the process of making available and amplifying

knowledge created by individuals as well as crystallising and connecting it to an organisation's knowledge system (Nonaka and Krogh, 2009). Although these studies have a focus on the individual level of knowledge transfer, they are mainly linked to organisations' performance indicators or the contribution to financial gains.

Braun and Hadwiger (2011, pg.S90) defined knowledge transfer as "the process concerned with the effective transfer of research related findings", whilst Darr and Kurtzberg (2000, pg.29) defined it as "an event through which one organization learns from the experience of another". A combination of these two definitions is followed in this research. An investigation of both research related findings, together with tools and processes is the main focus of this study. An element of learning is also present on all the projects, which will be explained in detail in the findings chapter.

2.3.2 CURRENT THEORIES RELATED TO KNOWLEDGE TRANSFER

Individual's actions, decisions, behaviours and motivations present the core of the investigation into the transfer of knowledge. However, most prior research has examined knowledge transfer either by only considering the actors involved or by simply focusing on the decomposed process itself from a particular angle. The knowledge transfer literature identifies interdependent streams of knowledge transfer, as the examples summarised in Table 1 show, and these are discussed in the following section (comprehensive table in Appendix 1). The literature includes those focused on motivations and assessing the psychological side of relationships; those focused on the process itself, its structure and various stages; those focused on the economical and performance impact of knowledge transfer; and those focused on relational aspects such as trust, learning, networks and social exchange.

Table 1: Overview of prior literature related to Knowledge Transfer

Study	Primary Focus	Theoretical Angle	Methods and Level of Analysis	Relevant Findings
Motivational Perspective				
D'Este and Perkmann (2011)	Focus on individual motivations (micro). Examine classic technology transfer "mechanisms", including patenting, spin-offs, collaborative research, joint research, contract research and consulting.	Entrepreneurial university literature. Triple helix theory. Ambidexterity.	Survey 1500 questionnaires Individual level	Patenting and spin-off company formation are motivated exclusively by commercialization whilst joint research, contract research and consulting are strongly informed by research-related motives.
Göktepe-Hulten and Mahagaonkar (2010)	Understand scientists' patenting activities and motivations.	Norms and rewards. Patenting literature.	Survey Individual level	Researchers engage in patenting not for personal profit but to signal their achievements and gain reputation amongst

				their academic and industry-related communities.
Lam (2011b)	Diversity of motivations Adopts a broader and psychologically richer notion of motivation - extrinsic as well as intrinsic aspects	Self-determination theory in social psychology.	Mixed methods Interviews Regression analysis Individual level	There is a diversity of motivations for commercial engagement, and that many do so for reputational and intrinsic reasons and that financial rewards play a relatively small part
Process Perspective				
Darr and Kurtzberg (2000)	Examined how the similarity between tasks affected the transfer of knowledge.	Knowledge transfer	Mixed methods Organisational level	"Strategic similarity" (similarity of the strategies and tasks) positively affected transfer of knowledge, whereas similarity of customers or location had no effect.
Szulanski (2000)	Knowledge transfer process stages and problems predicted by analysing stickiness.	Knowledge transfer	Cross-sectional analysis Two-step survey Organisational level	Factors such as the reliability of the source, predicted difficulty of transfer during the early initiation stage, whereas factors such as the recipient's ability to absorb knowledge, affected difficulty during the implementation phases
Blumenberg et al. (2009)	Transfer of explicit or tacit knowledge	Knowledge transfer	Case studies Organisational level	The combination of content and sender-receiver dimensions designed to transfer explicit and tacit knowledge has the most influence on the level of shared knowledge.
Economical Perspective				
Knockaert et al. (2011)	How knowledge to be transferred and employed in science based entrepreneurial firms (SBEFs) enhance their performance	Knowledge-based theory and upper echelons theory	Longitudinal inductive case studies Organisational level	In the creation of academic spin-offs, commercial expertise/mind-set and tacit knowledge is most effectively transferred when a substantial part of the original research team joins the new venture as founders.
Kotha et al. (2013)	Commercialization of interdisciplinary research, from distant scientific domains, is different from commercialization of inventions from specialized or proximate domains	Knowledge-based theory	Interviews Documentation (3,776 university invention disclosures) Organisational level	Knowledge transfer is significantly influenced by coordination costs Prior licensing and collaboration experience increases the hazard of licensing an invention
Williams (2007)	Firms replicate because knowledge is ambiguous and adapt because knowledge depends on context.	Replication and adaptation	Survey Organisational level	Adaptation and replication are distinct transfer mechanisms that firms use simultaneously when transferring knowledge. They lead to successful knowledge transfer, which leads to improved performance.
Relational Perspective				
Inkpen and Tsang (2005)	Social capital dimensions of networks (structural, cognitive, relational) and their effect in KT	Social capital Network types Knowledge transfer	Conceptual Organisational level	Each network type has distinct social capital dimension. For effective and efficient KT, firms must build social capital proactively.
Santoro and Saparito (2006)	How assumptions of a partner's self-interest and interorganisational trust affects KT in dyadic university-industry relationships	Knowledge transfer Interorganisational relationships Self-interest	Survey Organisational level	Both self-interest assumptions and relational trust are positively associated with greater KT. As knowledge becomes more tacit, self-interest assumption becomes negatively associated with KT while relational trust becomes more strongly positive.

		Relational trust		
Reagans and McEvily (2003)	How two properties of network structure – social cohesion and network range – affect KT	Absorptive capacity Associative learning	Survey Organisational level	Social cohesion and network range ease KT, over and above the effect for the strength of the tie between two people.

2.3.2.1 Motivational perspective

Knowledge transfer has been investigated from motivational angles. D'Este and Perkmann's (2011) study, on the entrepreneurial university and on the motivations as to why academic scientists in the physical and engineering sciences have to engage with industry, concluded that most academics engage with industry to further their research rather than to commercialise their knowledge. Similarly, Lam's (2011b) and Göktepe-Hulten and Mahagaonkar's (2010) study of the motivations for scientists to pursue commercial activities concludes that reputation and intrinsic reasons play a larger part than financial rewards for commercial engagement. These studies focused on motivational drivers for academic-industry engagement and knowledge transfer using large scale studies. Thus, although relevant to this study, they do not look at particular projects in depth and detail but instead focus on general motivations.

Owen-Smith and Powell (2001) argue that academics are motivated by monetary profit. They suggest that researchers in the life sciences use patents to increase their income, whilst in the physical sciences, researchers pursued relationships with firms to access equipment or exploit other research-related opportunities. Reagans and McEvily (2003) proposed that the motivation of why individuals invest time, energy and effort into knowledge transfer is directly related to social cohesion, network range and ties to different knowledge pools.

Although there seems to be a discordance on the motivations of academics for engaging with industry, the studies agree that there is a diversity of both intrinsic and extrinsic motivations. Whilst one group reveals intrinsic reasons such as reputation and research support, the other group reveals commercialisation-maximising motivations such as increased income through patenting. These studies also view patenting, spin-offs, collaborative projects, joint-research and so on, as mechanisms for knowledge transfer which is a different approach to this study. The goal in this study is to look beyond the motivations into the generative causal mechanisms, with the intention to develop an explanation rather than correlations. Thus, the term mechanism used in these studies has a different meaning than in this research, both ontologically and epistemologically.

2.3.2.2 Process perspective

Many studies have looked at knowledge transfer as a process and considered its various stages. Blumenberg et al. (2009) explained the effects of knowledge transfer outcomes on performance. They argued that the transfer processes for explicit and tacit knowledge should be viewed from two dimensions: the content dimension and the sender–receiver dimension. It is the combination of these dimensions that most influence the level of shared knowledge, which positively relates with performance. This study views knowledge transfer as a mechanismic activity where, for example, formal training and agreements (content dimension) and documented interactions between parties (sender-receiver dimension) play an important role in knowledge transfer activities.

Szulanski (2000) recognises that knowledge transfer is a process and not an act. By looking at different stages of transfer and the factors that correlate to difficulty of transfer challenges, he argued that the factors that affected the perception of an opportunity to transfer knowledge, such as the reliability of the source, predicted difficulty of transfer during the early initiation stage; whereas factors that affected the execution of transfer, such as the recipient's ability to absorb knowledge affected difficulty during the implementation phases. This process view is closely related to reputation and absorptive capacity (Cohen and Levinthal, 1990) where the former relates to reliability based on past performance, and the latter is based on individuals' capabilities to identify and assimilate value in the knowledge being transferred.

Kachra and White (2008) advocate that knowledge is shared with another firm subject to adequate compensation and reciprocity expectation for the effort expended in the transfer process, which again offers a dual perspective of financial gain and relational expectation. A further study by Darr and Kurtzberg (2000) looked at the process of knowledge transfer from a partner similarity perspective. They argue that the similarity of the strategies and tasks positively affected transfer of knowledge, whereas the similarity of customers or location had no effect. Their study looks at how firms can leverage their knowledge by partnering with other firms with similar strategic goals and the importance of sourcing these partners. Previous studies showed that the transfer of knowledge from one location to another positively enhances organizational learning, but their study argues that location has no influence on knowledge transfer.

There is a focus among process-based studies on knowledge transfer that directly links to firms' performance. These studies tend to be closely related to inter- or intrafirm knowledge transfer rather than to science-industry relationships. However, some frameworks offer a very

general knowledge transfer view that could be applicable to most relationships of this kind. Variables such as location, partner selection, formal agreements and absorptive capacity all play important roles in the process of transferring knowledge. However, these studies look at how these variables positively or negatively influence knowledge transfer and performance, which is a different intention from this study. Although the aim in this study is to investigate the process of knowledge transfer within each project, the purpose is not to evaluate what was done nor to investigate different phases, but to understand why knowledge was transferred. By analysing the structural side of each project, including resources, norms and rules; and also by investigating individuals' actions and interactions, an explanation for why the process of knowledge transfer happened is constructed.

2.3.2.3 Economical perspective

Researchers have examined knowledge transfer from a transaction cost economics perspective. Katz and Martin (1997) suggest that academic-industry collaborations can be prolonged by economic commitments, which create a 'locked-in condition' between partners, therefore ensuring that the cooperation is continued and endured. Another economic lens used to view knowledge transfer is the prisoner's dilemma of collective action (game theory) which suggests that information asymmetry and independent strategies within firms that are transferring knowledge, can cause conflicting interests in learning, which could lead to the end of the collaboration (Samieh and Wahba, 2007).

The knowledge-based view of the firm sees access to, and the development, protection and transfer of knowledge, as a means of creating and preserving competitive advantage (Grant, 1996). Therefore, from a company's point of view, knowledge is a term that can generate or conserve competitive advantage (Knockaert et al., 2011). Consequently, knowledge and intellectual capital become more important capabilities and value drivers than physical assets. Competitive advantage depends on how well a company enhances its own knowledge base, integrates knowledge and procures knowledge to either develop or improve products (Knockaert et al., 2011). In addition to that, businesses need the ability to recognise the value of new knowledge and information at the right time (Cohen and Levinthal, 1990). At the early stage, knowledge leads to some issues around attracting financing from the universities point of view. This is because companies in many cases have difficulties imagining the final results of university cooperation (Knockaert et al., 2011).

Argote and Ingram (2000) also studied transfer of knowledge as a basis for competitive advantage in firms. They provide insights into the reasons why it is difficult to transfer

knowledge and into the conditions under which knowledge transfer is most likely to happen. For example, they have shown that attaining compatibility between the subnetworks moved from one site to another is even more problematic than attaining compatibility of the knowledge reservoirs of people, tools, or tasks. These knowledge reservoirs directly affect knowledge transfer and consequently an organisation's competitive advantage.

Van de Ven (2007) suggests that knowledge is more likely to be shared and used if the recipient perceives that the new knowledge will give them an advantage over other competitors. He further explains that knowledge is more likely to be adopted when the stakeholders have been involved in the process of knowledge creation. He refers to engaged scholarship and the importance of collaborative work between research and practice, which produces knowledge that is more penetrating and insightful than when researchers work alone. This perspective offers a traditional view of science-industry knowledge transfer activities, with economic-type gains to businesses and reputational-type gains to researchers.

Chen et al. (2014) also examined knowledge transfer from a cooperative competency angle. They studied knowledge transfer cases and the relationship among transfer mechanisms (replication and adaptation), cooperative competency and knowledge transfer performance. By viewing knowledge transfer as a socially collaborative construct, they examined the ability of across firm interaction (cooperative competency) through trust, communication and coordination, and its effect on knowledge transfer outcomes. They concluded that mechanisms such as replication and adaptation positively affect cooperative competency which facilitates knowledge transfer performance. "Replication emphasizes recipients' significant efforts towards creating an identical set of activities to those of the sending partner" (pg.2532) leading to trust and friendship. "Adaptation coordinates knowledge transfer activities and makes communications and information exchanges between employees of the recipient and sending firms more conveniently (pg.2533)", increasing smoothness, openness and transparency between partners.

These studies posit a strong focus on economic gains that firms can potentially attain from knowledge transfer activities with either science-academic partners or other firms. One of the assumptions is that there is a danger that firms will not want to adopt the new knowledge, or fail to understand the purpose of the new knowledge. Mechanisms such as economic contracts, replication, adaptation, engaged scholarship, knowledge reservoirs and so on, are seen as useful tools that can improve knowledge transfer and increase competitive advantage. Divergent to these studies, this research does not view mechanisms as tools but as a process by which an effect is produced. Therefore, although these studies provide strong evidence that

these tools improve competitive advantage, they fail to explain why this is the case. By looking further beyond the tools, it is possible to create a narrative that explains knowledge transfer in the projects within this research.

2.3.2.4 Relational perspective

Santoro and Saparito (2006) examined SMEs working with university research centres and concluded that relational trust and self-interest assumptions are positively associated with greater knowledge transfer. Other studies looked at knowledge transfer from an individual's trust perspective and the importance of boundary spanning individuals to trust the other's organisation (Zaheer et al., 1998). Both interpersonal and inter-organisational trust are considered key drivers for knowledge exchange performance, with the former affecting institutionalisation, and the latter associated with lowered costs of negotiation and conflict.

Another relational angle investigated is from a social capital perspective, particularly in relation to social networks and network ties. Adler and Kwon (2002) suggest that informal social ties are superior conduits for knowledge sharing between different organisations, especially those in geographically dispersed locations whilst Nahapiet and Ghoshal (1998) studied the relationship between network characteristics and knowledge transfer, demonstrating that network ties provide better access to resources and assistance in solving problems (Reagans and McEvily, 2003). Other studies suggest that the relationship quality and trust between firms have a strong positive association with knowledge transfer and organisational learning. They suggest that without human actions, knowledge would not be able to be created and amplified (Nonaka and Takeuchi, 1995).

Inkpen and Tsang (2005) examined how social capital dimensions of networks – structure, cognition and relation - affect the transfer of knowledge. By examining how organisations acquire knowledge depending on their positions within networks, they concluded that organisations should build and use their social capital proactively for efficient knowledge transfer. This view is also shared by Yli-Renko et al. (2001), who suggest that knowledge transfer is facilitated by the intensive social interactions of organisational actors.

Another widely cited theory to explain knowledge transfer is absorptive capacity (Cohen and Levinthal, 1990), which implies that knowledge transfer is only successful if the receiver of the information has prior related knowledge in order to recognise the value of what they are receiving, and to be able to assimilate it effectively. Therefore, the success of knowledge transfer is greatly affected by the receptivity of the recipient of knowledge. Szulanski (1996) analysis of knowledge stickiness, concluded that a major barrier to knowledge transfer is the

recipient's lack of absorptive capacity, which affects the execution and implementation of the transfer.

Knowledge transfer has been studied using social exchange theory, which refers to situations where firms provide rewards or punishments in recurring interactions. Muthusamy and White (2005) found that social exchanges such as reciprocal commitment, trust and mutual influence between firms are positively related to knowledge transfer. Whereas economists assume that firms' behaviours towards knowledge transfer are motivated by self-interests, the social exchange theorists believe that knowledge transfer can be motivated by a broad array of interests and those self-interests and group interests can coexist (Kachra and White, 2008).

Lam's (2007) study focused on the knowledge flow between scientific knowledge networks and industry, and how that is related to human resource issues, particularly to address relatively new career frameworks. It takes into account two perspectives on how these frameworks address knowledge transfer: cognition and competencies versus careers and incentives.

Another interesting position, proposed by Liyanage et al. (2009), is a process model of knowledge transfer using the theory of communication and theory of translation. They argue that knowledge transfer is facilitated by collaboration (theory of communication) and transformation of knowledge into usable form (theory of translation). This view is also shared by Holden and Von Kortzfleisch (2004) who argue that the perceived utility of knowledge from the receiver determines the effective translation and quality of the knowledge transferred. Holden and Von Kortzfleisch (2004) used translation theory as an applicable analogy to explore the nature of knowledge transfer and go a step further to explain that the process is only successful if the source understands their own knowledge and if they understand what it means to the receiver. Thus, this translation involves the interpretation of the same knowledge in a different manner or context in order to be accessible and absorbed.

While studies have emphasised the importance of relational aspects such as trust, they have either assumed a self-interest angle (Santoro and Saparito, 2006), a cooperative competency perspective (Chung-Jen et al., 2014) or a relational trust angle (Van de Ven, 2007). These studies presented investigations of how trust, both interpersonal and interorganisational, affect knowledge transfer and consequently firms' performance. However, these studies to not explain the generative mechanisms of trust.

Relational trust, for example, offers a sense of obligation and expectations that enter into academic-industry relationships, giving rise to psychological contracts and even shared

beliefs. The mechanism of why this happens is not investigated. Could trust be explained by a mechanism of reciprocity or self-interest? The former could explain trust as an important element on knowledge transfer relationships because academics expect to receive funding in exchange for research findings. The later could explain trust because academics work in a self-interested way to further their own research.

2.3.2.5 Conclusion

The strength of these approaches is that they provide a plethora of perspectives and correlations within the knowledge transfer literature. Even though most of these studies come from a strong positivist tradition in terms of their design, approach and analysis, they offer interesting insights that are important to both theory and practice. Firstly, knowledge transfer is a highly complex phenomenon with various contextual issues. Secondly, various components are pivotal for successful knowledge transfer such as trust, network ties, absorptive capacity and learning. Thirdly, the importance of individual motivations is very pertinent, both intrinsically and extrinsically. Fourthly, there are both structural and communication elements of knowledge transfer that impact on organisational performance. In a business environment, knowledge transfer takes place through communication, tools, interventions, intermediaries, socialisation and so on, making these insights relevant and contemporary.

One class of explanations is grounded in social psychology theories (Samieh and Wahba, 2007) such as self-determination (Lam, 2011b) and social exchange (Muthusamy and White, 2005). These studies focus on elements such as reciprocity and learning. Fundamentally, issues concerning knowledge transfer lie at the heart of most of these theoretical approaches. Others are grounded on the embedded nature of knowledge transfer such as network ties (Reagans and McEvily, 2003). These studies focus on opportunism and transactional cost economics. However, these studies do not resolve why knowledge transfer happens.

As can be observed from the aforementioned studies, many of the possible characteristics necessary for knowledge transfer have already been identified in the academic literature. Despite the voluminous literature on knowledge transfer, it is surprising that studies have not yet investigated generative mechanisms. So far it has been difficult to provide in-depth recommendations on why knowledge transfer occurs. This study aims to advance prior research by offering an alternative perspective, with different epistemological assumptions about cause and effect, grounding the knowledge transfer literature in a more robust framework

based on a process-oriented view, by investigating the underlying mechanisms that enable knowledge transfer in science – industry projects.

2.3.3 CURRENT MODELS ON KNOWLEDGE TRANSFER

Examples from previous studies demonstrate that knowledge transfer is not a straight-forward activity, but rather a continuous struggle of encountering and overcoming challenges. Despite the process-orientated dimensions of knowledge transfer, prior empirical studies have generally operationalised it as a single dependent variable associated with a range of possible antecedents. Existing frameworks were designed to catalogue the many variables and complexity of knowledge transfer, rationalising assumptions on how it should occur. Thus, they provide insights into the process of knowledge transfer and its requirements for the commitment of resources, time and effort to improve communication and build trust, for firms to be able to leverage their ability to interact effectively with partners.

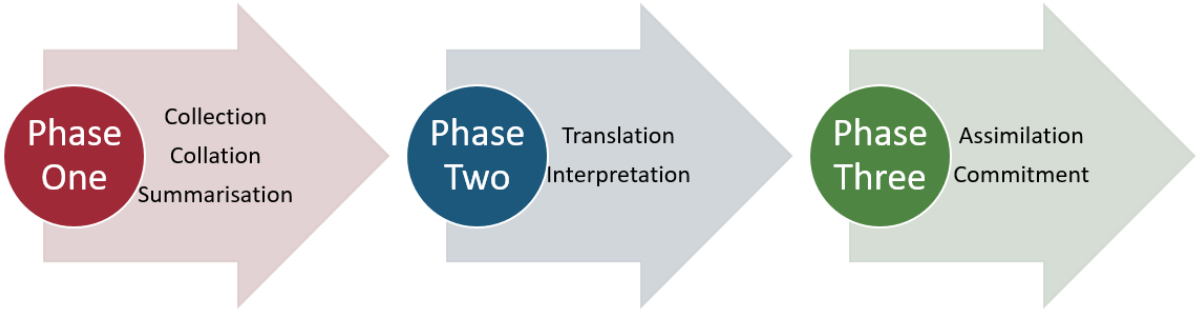
Major and Cordey-Hayes (2000) look at several frameworks and models of knowledge transfer, and distinguish two streams of models: node models and process models. Node models describe nodes and the discrete steps of a knowledge transfer process. For example, Slaughter's (Slaughter, 1994) model proposes a hierarchy of knowledge, or nodes, which in this case are data, information, knowledge and wisdom, summarised in Figure 4. He suggests that knowledge transfer starts from disorganised data, passing through each node or stage until it reaches wisdom, which is the last stage and the basis for action, providing a very basic model that portrays knowledge as one stage in a linear model.

Figure 4: Slaughter's "nodes" hierarchy of knowledge transfer model

Process models describe knowledge transfer by separate processes that are each undertaken. For example Horton's (1999) model has three phases for knowledge transfer – (1) collection, collation and summarisation; (2) translation and interpretation; (3) assimilation and commitment. This model is summarised in Figure 5. The first phase – collection, collation and summarisation – refers to when organisations scan for ideas, raising their awareness of opportunities and processing the value of this information to the organisation. The second phase – translation and interpretation – refers to when the information collected and summarised is translated into understandable language, and where value is recognised. The

last phase is assimilation and commitment, which refers to when the value found is transferred into action.

Figure 5: Horton's (1999) three phase model



This model is analogous to Trott's (1995) model of inward technology transfer which includes awareness, association, assimilation and application. Awareness is the phase where companies scan for ideas and association is when they recognise the value of those ideas. Assimilation refers to the process of creating opportunities from the ideas and application is when organisations apply the technology for competitive advantage.

The Triple-Helix model of industry-policy-knowledge relationships was introduced into the academic and policy worlds by the work of Leydesdorff and Etzkowitz (1996). They argued that these triple relationships are influential in the shaping of systems for innovation and growth (Leydesdorff and Etzkowitz, 1998, Etzkowitz and Leydesdorff, 2000). This is a prominent model that offers a dynamic framework of interactions among the three spheres, focusing on the potential power of these relationships. It goes beyond the dual interaction between industry and academia, to include policy and government. It also suggests a reorientation of academia and universities away from pure inward-looking research towards a more open interaction with industry and government, and the commercialisation of created knowledge.

A similar triplicate analytical model proposed by Böcher (2016) is the RIU model. This model understands scientific knowledge transfer as the connection between research (R), integration (I), and utilisation (U), as summarised in Figure 6. It reflects that high-level scientific research should have an integration step between research and practical utilisation. Integration is defined as "the exchange of information in response to the demands of those in practice and in evidence gathering" (Böcher, 2016, pg.66). This integration step is analogous to Horton's model phase two, where research results that are relevant for industry are select based on practical demands and perceived value.

Figure 6: The RIU model of scientific knowledge transfer

Liyanage et al. (2009) proposed a very comprehensive knowledge transfer model, where the number of steps taken in a knowledge transfer process can be reduced if the source and the receiver are similar either contextually, technically, or structurally. By including other models such as Nonaka and Takeuchi's (1995) modes of knowledge transfer – socialisation, externalisation, combination, and internalisation – together with Trott et al.'s (1995) framework on the stages of knowledge transfer – awareness, acquisition, transformation, association and application – they built a model on the source and receiver. They suggest that the source should understand the relevance of knowledge to the receiver and be willing to share it. The receiver should have absorptive capacity and a willingness to acquire the knowledge.

These models offer an assessment "tool" and practical guidance to assist the understanding of knowledge transfer stages and raise awareness of context and problems in different stages. For example, the Triple Helix model goes beyond dyadic relationships and offer insights into the dynamics of the relationship among research, industry and government. Most of these models, although contextually different, have strong similarities. They take into account the processes and stages of knowledge transfer and provide a framework to map the landscape of knowledge transfer.

However, these models have limitations. They fail to include an individual level of analysis, focusing mainly at macro levels. Therefore, they do not inform the internal transformations of each sphere or stage, particularly in terms of individual actors. They assume that all stages or phases are completed in a linear fashion and that data or information is available and can be translated into knowledge. Most importantly, none of these models answer the why questions, only how the process of knowledge transfer happens. By not taking into account the interaction of actors and their motivations, it would be difficult for these models to fit into different contexts.

2.4 Knowledge Transfer in the Food Industry

The importance of knowledge and technology transfer in the food and drink sector is made clear when one takes into account that 99.1% of the population of the European food and drink

businesses are SMEs, they provide 63% of all jobs in the private sector and generate 48.7% of the turnover (CIAA, 2009). Despite being known as a relatively traditional and mature industry, the food sector increasingly does take innovation from actors inside and outside the value chain (Sarkar & Costa, 2008).

Universities and research institutes offer a range of supporting mechanisms that accelerate innovation and entrepreneurship including research capabilities, investments, collaboration and spin-offs. Food research institutes also have a big impact within the food industry and are seen as crucial for assisting with the innovation activities of businesses. Even though the value of pure science is seldom questioned, the current *modus operandi* and relationship with industry requires more attention (Merchán-Hernández et al., 2015).

Scientific knowledge transfer in the food sector is a relevant topic as organisations, particularly SMEs, often lack access to sources of innovation which they need to stay competitive. Braun and Hadwiger (2011) outline that trust and language are the key obstacles that hamper the transfer of scientific insights to SMEs in the food sector. However, with most food companies being SMEs, these challenges need to be addressed and researched further.

Blundel (2002) explored the transfer of knowledge in a networks setting, by studying artisanal food producers and their growth trajectories utilising their business networks. By looking at two case studies of cheese makers, they traced their developments over five decades. He concluded that upstream and downstream network relationships have played a key role in capability development, and explain their growth as the product of a complex mix of interacting forces such as the increased demand for organic products and internalisation of learning from their networks. Similar to previous studies in the knowledge transfer literature, network ties, formal memberships and social capital are well studied elements which seems to consistently positively affect these relationships.

There are also some nationwide studies on the food sector that relate to knowledge transfer. Ciliberti et al. (2016) study drivers for innovation and knowledge transfer in the food industry in Italy, and how these drivers differ from those in the pharmaceutical industry. By using data from a large nationwide survey, they concluded that the food industry is strongly dependent on the acquisition of external technology to produce innovation, requiring both absorptive capacity and strong collaboration with academic research. Another study by Brännback and Wiklund (2001) on the changes in the food industry in Finland, from traditional to functional foods, looked at how this change required an update in knowledge transfer and management. They look at this change from a dominant logic point of view and propose that it will increase the

knowledge complexity turning a traditionally low-technology industry into a high technology one. Functional foods and similar research on food and health are a strong trend in the food industry in the UK and worldwide, making this kind of understanding relevant for future research.

Manniche and Testa (2010) looked at knowledge dynamics in the food sector and suggested a conceptual framework with a combination of synthetic, analytical and symbolic (SAS) and world of production (WOP) models that would help investigations and interpretation of knowledge dynamics. Whilst the SAS model regards knowledge bases of firms and distinguishes between synthetic (engineering-based), analytical (science-based) and symbolic (artistic/creativity-based) knowledge, the World of Production (WOP) model classifies firms according to differences in technologies and markets and outlines four possible action frameworks within which companies operate and innovate. They argue that the food industry has strong symbolic knowledge and suggest generating new symbols and meanings embedded in the products rather than only developing and producing food for improving food production.

According to the aforementioned studies in the food industry, we can see that they have been either larger scale surveys (i.e. (Ciliberti et al., 2016) or specific small-n case studies in sub-sectors in the food industry (i.e. Blundel (2002) in artisanal food producers), the latter resonating more with this research. However, instead of coming from a particular theoretical angle, this study is set to discover generative mechanisms within specific knowledge transfer projects. The previous studies have also looked at macro level elements and have not considered micro foundations. They do, though, offer very robust frameworks to study knowledge transfer processes, as well as interesting longitudinal studies (Blundel, 2002) that provide detailed macro explanations on the influence of environment turbulence, reaction to changes, and the importance of networks, trust and language.

2.5 Conclusion

This section provided an overview of knowledge definitions, and also a critical review of the extant literature in relation to knowledge transfer. Knowledge is a complex construct that involves human cognition, decision-making and learning. By tracing the literature on knowledge transfer, it is clear that the interest in this topic is vast and ever-growing.

For the context of this research, the pressure faced by public research institutes to commercialise their research has driven researchers to investigate the drivers for knowledge

transfer and commercialisation, for example, individual's motivations for knowledge transfer between academia and industry (D'Este and Perkmann, 2011, Göktepe-Hulten and Mahagaonkar, 2010, Lam, 2011b). Key theoretical angles in studies of knowledge transfer include competitive advantage (Knockaert et al., 2011), absorptive capacity (Reagans and McEvily, 2003), self-determination theory (Lam, 2011b), human resource management (Lam, 2007), boundary spanning (Zaheer et al., 1998), trust (Santoro and Saparito, 2003), social capital (Inkpen and Tsang, 2005), economics (Lee and Cavusgil, 2006), translation theory (Liyanage et al., 2009), and social exchange theory (Muthusamy and White, 2005).

There are many models that seek to understand the process of knowledge transfer, for example the triple helix model (Leydesdorff and Etzkowitz, 1996), the three phase model (Horton, 1999), the hierarchy nodes model (Slaughter, 1994), and the RIU model (Böcher, 2016). Even with the considerable literature on knowledge transfer, there are gaps:(1) these studies have either looked at micro or macro levels and relationships separately, or (2) they have proposed correlations between variables but not causation, or (3) they have viewed knowledge transfer from a particular theoretical angle, or (4) they have a strong positivist stance and are situated at the empirical level, therefore not looking further into generative mechanisms or (5) they do not provided an explanation as to why knowledge transfer happens.

What remains unclear is: (1) a detailed explanation as to why knowledge transfer happens in science-industry relationships, (2) what are the underlying generative mechanisms at both micro and macro levels, and (3) what are the actions and interactions of individuals that participate in these relationships. Thus, there are a paucity of inductive studies that look for fine-grained explanations of why this process happens. This study proposes an inventive analytical framework that looks at the macro and micro levels by uncovering the underlying generative mechanisms within the three projects at IFR. This framework is detailed in the Methods chapter. The subsequent section ties in with the preceding discussion of knowledge transfer in the food industry, by providing an overview on current challenges in this sector. It will also provide an overview of IFR and the context in which this research was conducted.

3 THE FOOD SECTOR AND STUDY SETTING

3.1 INTRODUCTION

The food sector in the UK is composed of approximately 5,800 small and medium sized enterprises (SMEs), accounting for 30% of employment and 26% of turnover (Defra, 2014). Collaboration with external partners becomes increasingly important due to the complexity of the processes to tackle food issues. This sector is highly regulated and aspects such as food safety, hygiene and health are heightened. The food industry is currently facing many challenges, such as: a growing population (FAO, 2013); an ageing population (Miller and Welch, 2013); limited resources such as water, energy and land (Foresight, 2011); maintaining a sustainable food supply whilst adapting to climate change (Garnett, 2014); livestock welfare (Maloni and Brown, 2006); traceability and authenticity (Thompson et al., 2005); food waste (Gustavsson et al., 2011); and food security including access, utilization and availability (GECAFS, 2011b, Rayfuse and Weisfelt, 2012, Whipple et al., 2009).

The following section aims to explore some of these challenges, particularly related to food and health, food safety and food regulations. Secondly, a more detailed description of IFR and the setting of this study will be offered. Finally, there will be an overall description of the policy environment that influences the wider environment of this study such as the Biotechnology and Biological Sciences Research Council (BBSRC), Knowledge Transfer Partnerships (KTPs) and the Research Excellence Framework (REF).

3.2 FOOD SECTOR CHALLENGES

Agricultural practices in the UK have changed drastically over the past century. The unprecedented yield increases of the Green Revolution in the 1960s, however, were not obtained without cost to our environment. The advancement in technologies and industrial applications has also meant that the number of farm operators has decreased and agriculture has had a shift from a focus on productivity towards sustainability. Food systems have become a national and global preoccupation. Consumers increasingly demand to know how food is produced and by whom, how it is transported, processed and packed and how nutritious the food is that they are consuming.

The food industry in the UK is quite extensive and one of the most important branches of the national economy. It employs over 400,000 workers, which represents 15% of the overall manufacturing workforce in the UK. It is also the largest manufacturing sector in the UK, with a turnover of £76bn, which accounts for 16% of the total manufacturing sector (FDF, 2014).

There are over 6,380 enterprises in the UK food manufacturing sector, with high relevance for employment and economic output. The largest turnover size band is £100K-£249k which accounts for 20.6% of the market. The turnover bands can be grouped into small companies (£1k - £249k), medium companies (£250k - £999k) and large companies (over £1 million). Small companies make up 42.8% of the market; medium sized companies make up 23.4%, while large companies make up 33.7% (ONS, 2011).

Food balance sheets present a comprehensive picture of the pattern of a country's food supply during a specified reference period (FAOSTAT, 2009). The food balance sheet shows for each food item – i.e. each primary commodity and a number of processed commodities potentially available for human consumption – the sources of supply and its utilization. It is made up of three sets of data including supply (production, imports and change in stocks), utilization (exports, feed, seed, food and other use) and per capita food supply (population nutrient content – calories, protein, fat).

The UK imports over 68 million metric tons of food products every year (FAOSTAT, 2009). Many of these imports are from countries with more relaxed traceability and sanitation food standards, which could potentially lead to product contamination. Whilst around half of domestic consumption (in unprocessed terms) is supplied by domestic agriculture, this itself can be a significant source of risk because of the potential for domestic animal disease, floods, crop failures, radioactive fallouts, boycotts and so on. Domestic agriculture is also exposed to breakdowns in trade as it is itself dependent upon imports of feed, fuel, machinery and fertiliser (Defra, 2010).

3.2.1 Food Waste

Reducing food waste is an economic, ethical and environmental challenge which initiatives are starting to address. Poor practices when harvesting, storing and transporting the food, as well as market and consumer wastage, are responsible for this waste. Gustavsson et al. (2011) point out that the terms "food losses" and "food waste" are described in slightly different ways depending on the literature and context. "Food loss" is usually defined as the loss of edible food during harvesting, on-farm storage or transport for food processors. "Food waste", on the other hand, is often defined as losses that occur at the retail and consumer levels of the food supply chain. These losses are primarily determined by the behaviours of retailers and consumers, for example, when edible food is discarded because of blemishes or because it is past the "best before" date.

The world currently produces 4 billion metric tons of food per annum. It is estimated that 30-50% (or 1.2-2 billion tonnes) of all food produced is wasted and never reaches consumers (IMechE, 2013). This means that large amounts of the resources used in food production and distribution such as water and energy are used in vain, as well as creating unnecessary greenhouse gas emissions.

In less-developed countries, such as those of sub-Saharan Africa and South-East Asia, wastage tends to occur primarily at the farmer-producer end of the supply chain. Inefficient harvesting, inadequate local transportation and poor infrastructure mean that produce is frequently handled inappropriately and stored under unsuitable farm site conditions. In mature, developed countries such as the UK, more efficient farming practices and better transport, storage and processing facilities ensure that a larger proportion of the food produced reaches markets and consumers. However, characteristics associated with modern consumer culture mean produce is often wasted through retail and customer behavior. A study conducted by the Swedish Institute for Food and Biotechnology (Gustavsson et al., 2011) concluded that food waste in industrialized countries such as the UK can be reduced by raising awareness among food industries, retailers and consumers. There is a need to find good and beneficial use for safe food that is presently thrown away.

Miller and Welch (2013, pg.115) claim that “food processing can reduce food waste, prevent nutrient losses, increase nutrient content through fortification, enhance the acceptability of foods to consumers, reduce risk of foodborne illness, provide jobs and economic development, and reduce the time and energy required for home food preparation”. On the other hand, many current food processing manufacturers produce food with inferior nutritional value by adding fat, sugar and salt which is harmful for overall health.

The food system makes extensive use of non-renewable resources and consumes many renewable resources at rates far exceeding replenishment without investing in their eventual replacement. It releases greenhouse gases, nitrates and other contaminants into the environment. Directly, and indirectly through land conversion, it contributes to the destruction of biodiversity. Unless the footprint of the food system on the environment is reduced, the capacity of the earth to produce food for humankind will be compromised with grave implications for future food security. Consideration of sustainability must be introduced to all sectors of the food system, from production to consumption, and in education, governance and research (Defra, 2010).

3.2.2 FOOD SECURITY

The food value chain is facing challenges from well documented pressures, including food security, scarcity of water and energy resources, climate change and population growth (Foresight, 2011). Food security has recently been high in policy, societal and science agendas (Defra, 2006, Godfray et al., 2010). Most research around food security emphasises increasing crop productivity, i.e. yield, the impact of climate change on agricultural production, or the impact of agriculture on land use, pollution and biodiversity (Ericksen et al., 2009) and some livestock and fisheries also received attention (Ingram, 2011). The definition of food security has evolved from a more simplistic view from the World Bank "Access by all people at all times to enough food for active, healthy life" (WorldBank, 1986) to a more holistic definition from the Food and Agriculture Organization (FAO) which states: *"Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 1996).*

This concept involves ensuring that all people have not only have access to sufficient, safe and nutritious food to meet their dietary needs and their food preferences and ensure an active, healthy life (Rayfuse and Weisfelt, 2012). Although the concept of food security is deceptively simple, it is a complex and multidimensional issue that can be better understood when a suite of indicators are used that involve availability, access, utilization and stability (FAO, 2013).

The Global Environmental Change and Food Systems (GECAFS) Project was an international, interdisciplinary research effort to broaden the understanding of the links between global environmental change, food systems and food security (GECAFS, 2011b). They developed a broad framework that identifies the elements and relationships between food system activities and outcomes, which are represented in Table 2. One important outcome of human managed systems that is likely to be heavily influenced by current and future environmental change is food security, which depends not only upon the production of food but also on food access and utilization.

The GECAFS Food System Concept summarised in Table 2, draws from the definition of food security from the FAO and includes food access, utilization and availability at its core. This food systems approach provides a framework that involves both physical and social processes, and it includes a number of activities that give rise to a number of outcomes. Food access is very largely determined by affordability and the disposable income people have to spend on food. In terms of utilisation, the focus is on the cultural aspect of food, together with food safety and nutritional value. Availability is determined by the production and supply chain systems for

the distribution of food. All these elements need to be working together for food security to be met. The food systems activities all need to be done to achieve food security. Each activity is determined by a set of other elements, for example, processing and packaging food will be determined by the nature of the raw materials, storage requirements, and so on. Furthermore, as well as the outcomes of food security, there are a wider range of outcomes from the food systems activities that include the social and environmental spheres. Consequently, these outcomes will have a suite of other outcomes that will be affected by these activities.

Table 2: Food System activities and food security outcomes (GECAFS, 2011a)

The Food System Activities
Producing food
Producing food includes all activities involved in the production of the raw food materials. Key factors include farmers, hunters, fishermen, the multiple suppliers of production inputs including agrichemicals, agricultural labourers, and land owners.
Processing and Packaging food
Processing and Packaging food includes the various transformations that the raw food material (e.g. grain, vegetable, fruit, animal) undergoes before it is sent to the retail market for sale. Key factors include the middlemen who buy from producers and sell to processors; the managers and workers in processing and packaging plants; and trade organisations that set standards.
Retailing and distributing food
Retailing and distributing includes a range of middlemen who go between the producers, processors, packers and the final markets, and the many actors involved in e.g. transport, delivery and warehousing operations, advertising, trading and supermarkets.
Consuming food
Consuming includes all consumers themselves, and the varied actors that control what they consume, e.g., market regulators, advertisers, consumer groups.
The Food Security Outcomes
Food Availability
• Production = how much and which types of food are available through local production. • Distribution = how food is made available (physically moved), in what form, when and to whom. • Exchange = how much of the available food is obtained through exchange mechanisms such as barter, trade, purchase, or loans.
Access to food
• Affordability = the purchasing power of households or communities relative to the price of food. • Allocation = the economic, social and political mechanisms governing when, where and how food can be accessed by consumers. • Preference = social, religious or cultural norms and values that influence consumer demand for certain types of food.
Food Utilisation
• Nutritional value = how much of the daily requirements of calories, vitamins, protein, and micronutrients are provided by the food people consume. • Social value = the social, religious and cultural functions and benefits food provides. • Food safety = toxic contamination introduced during producing, processing and packaging, distribution or marketing food; and food-borne diseases such as salmonella and CJD.

3.2.3 FOOD SAFETY AND REGULATIONS

The Confederation of the Food and Drink Industries in Europe (CIAA) Competitiveness Report 2013-2014 stresses that the innovative potential of the European food industry should be enhanced by overcoming regulatory bottlenecks and supporting public-private partnerships (CIAA, 2014). The food and drink sector is the largest manufacturing sector within the EU and one of the main drivers of the EU economy (Menrad, 2004, Baregheh et al., 2012). Therefore, it has an enormous potential to generate and use innovation for economic growth and also improvements in wellbeing and quality of life.

The recent developments in nanotechnology, biotechnology and new preservation systems are unique opportunities to ensure food safety and more sustainable production. Most food manufacturers in the UK are SMEs which means that knowledge may need to be found outside its boundaries. Consequently, often companies establish collaborations with other actors of the supply chain such as suppliers, customers, research centres and even competitors. Although SMEs form a vital part of the food sector, there has been little previous research into the innovation and knowledge transfer practices of the food and drink SMEs (Baregheh et al., 2012). There has been some research conducted on the importance of networks and alliances (Avermaete et al., 2004) and product/process innovation (Capitanio et al., 2010) but there is a lack of empirical research focusing on who is involved in such activities and the nature of co-operation with research institutes (Avermaete et al., 2004).

Many innovations introduced in the food sector have been developed outside the processing industry, for example biotechnology and preservation technology (Chesbrough et al., 2006). This offers numerous opportunities for value-added applications for the food industry. An investigation by Knudsen (2007), based on a survey at an European level, of how inter-organizational relationships contribute to the success of new product development (NPD), concluded that sharing knowledge with external partners leads to positive innovation performance. More importantly, Knudsen (2007) highlighted that organisations operating in the food industry frequently use and are positively affected by collaborative involvement with suppliers and competitors, but less so with universities and consultants.

A study by Mortara and Minshall (2011) on open innovation implementation concluded that large organisations in the food industry tend to have a conscious adoption of Open Innovation with a top-down and centralised approach. Within such a demanding market where competition is very high, knowledge transfer is considered essential to sustain growth and reduce costs by sharing investments in R&D. Bigliardi and Galati (2013) stated that knowledge transfer in the

food industry remains highly challenging due the large number of actors involved in food production, from farmers to end consumers, who often have contradictory requirements. Accordingly, the sector should exhibit a variety of innovation strategies.

SMEs usually lack the full set of internal resources and competences to effectively develop, produce, and commercialise their innovations (Colombo et al., 2014). Innovation opportunities can be influenced by social concerns and pressure on the environment, public safety and corporate governance (Tidd, 2006). For instance, in the food industry genetically modified crops have taken different paths in the United States and Europe, mainly due to public concerns and pressure (Tidd, 2006)..

3.3 Policy Environment

3.3.1 Research Councils in the UK

Research Councils UK (RCUK) are responsible for investing £3billion per annum of public money into research in the UK with the aim to advance knowledge and generate new ideas which lead to a productive economy, healthy society and contribute to a sustainable world. RCUK is a strategic partnership which was established in 2002 and supports seven research councils covering the disciplines from the medical and biological sciences to astronomy, physics, chemistry and engineering, social sciences, economics, environmental sciences and the arts and humanities. It supports over 50,000 researchers including 19,000 doctoral students, around 14,000 research staff, and 2,000 research fellows in UK universities and in their own Research Institutes (RCUK, 2017).

RCUK introduced Pathways to Impact in 2009 to encourage its research councils to explore, from the outset and throughout the life of projects and beyond, who could potentially benefit from their research and what they can do to help make this happen. One of the implications from this initiative is that all research proposals must produce a clear Pathways to Impact statement as a condition of funding. Thus, Research Councils have agreed that if an application is considered excellent for research in terms of the proposed research but has a poor Pathways to Impact statement, the research will not be funded. The statement should be project specific and with a focus on potential outcomes.

IFR has also been impacted by the Pathways to Impact statement. Scientists are encouraged to identify and actively engage with different users and stakeholders, propose research that meet their needs and include any evidence of engagement with relevant users and stakeholders, such as food manufacturers SMEs. This engagement can occur in many ways:

through knowledge exchange, new products and processes, new companies and job creation, skills development, increasing the effectiveness of public services and policy, enhancing quality of life and health, and international development.

Each of the Research Councils is established under the Science and Technology Act 1965, as a body incorporated by Royal Charter. The Royal Charter is the legal document which sets out the role and mission of each Council. The Council body is responsible for setting each Research Councils' policy, strategy and priorities. It is also accountable for the stewardship of the Council's budget and the extent to which objectives have been delivered and targets have been met. Council members are appointed by the Secretary of the Business, Energy and Industrial Strategy (BEIS), who is answerable to Parliament for the Councils' activities.

Each Research Council has its own structure of high-level advisory boards and groups to identify opportunities for research, training and knowledge transfer and to provide external advice on the development of strategies and policies. Each Council body typically has between 15 and 18 members drawn from the Council's academic, business and user communities. The seven research councils are summarised in Table 3.

Table 3: Research Councils

Research Council	Establishment
Arts and Humanities Research Council (AHRC)	2005-date (12 years)
Biotechnology and Biological Sciences Research Council (BBSRC). Formerly Science and Engineering Research Council 1981-1994 and Agricultural and Food Research Council 1983-1994 (formerly Agricultural Research Council 1931-1983)	1994 – date (23 years, or 86 years including previous forms)
Engineering and Physical Sciences Research Council (EPSRC). Formerly Science and Engineering Research Council 1981-1994; formerly Science Research Council 1965-1981	1994 – date (23 years, or 52 years including previous forms
Economic and Social Research Council (ESRC)	1965-date (52 years)
Medical Research Council (MRC)	1920-date (97 years)
Natural Environment Research Council (NERC)	1965-date (52 years)
Science and Technology Facilities Council (STFC). Formerly Particle Physics and Astronomy Research Council 1994-2007 and Council for the Central Laboratory of the Research Councils 1995-2007	2007-date (10 years or 22 years including previous forms)

The seven Research Councils have common objectives, which are to:

- fund basic, strategic and applied research;
- support postgraduate training (PhDs and masters' students and fellows);

- advance knowledge and technology and provide services and trained scientists and engineers to contribute to the economic competitiveness, the effectiveness of public services and policy, and quality of life;
- support science in society activities.

Knowledge exchange is an important aspect from the research council's objectives and their aim is to improve exploitation derived from their investments. There are a number of initiatives that they support such as education and training, collaboration with industry, commercialisation of IP, entrepreneurial activities and so on. RCUK supports close interactions with the large number of SMEs as essential to encourage take-up of new ideas which could improve competitiveness. Research Council funds are awarded on the basis of applications made by individual researchers, which are subject to independent, expert peer review. Awards are made on the basis of the research potential and are irrespective of geographical location.

From 2018, the seven Research Councils and Innovate UK will be integrated into a into a single, strategic body with a combined budget of more than £6 billion. UK Research and Innovation (UKRI) will be a major voice for UK research and innovation in the UK and globally. UKRI has the objectives:

- a greater focus on cross-cutting issues that are outside the core remits of the current funding bodies, such as multi-and inter-disciplinary research;
- a strengthened, unified voice for the UK's research and innovation system;
- improved collaboration between the research base, business and the commercialization of discoveries;
- better mechanisms for the sharing of expertise and best practice – for example, around management of major projects and large capital investment;
- more time for research leaders to focus on strategic leadership through the centralisation of back and middle office functions; and
- improved quality of evidence on the UK's research and innovation landscape through the pooling of multiple datasets.

Funding Council support for research (Quality Related or QR funding) is distributed on the basis of the excellence of individual departments in higher education institutions, using the results of the Research Excellence Framework (REF), which was formerly the Research Assessment Exercise (RAE).

Under the dual support system, the Research Councils provide grants for specific projects and programmes, while the UK's Funding Councils provide block grant funding to support the research infrastructure and enable institutions to undertake ground-breaking research of their choosing. Such funding also provides the capacity to undertake research commissioned by the private sector, Government Departments, charities, the European Union and other international bodies.

3.3.2 BIOTECHNOLOGY AND BIOLOGICAL SCIENCES RESEARCH COUNCIL (BBSRC)

BBSRC is one of the seven Research Councils that work together as Research Councils UK (RCUK). BBSRC was established by Royal Charter in 1994 by incorporation of the former Agricultural and Food Research Council (AFRC) with the biotechnology and biological sciences programmes of the former Science and Engineering Research Council (SERC – 1981-1994). They are funded by the Government's Department for Business, Innovation and Skills (BIS) and their annual budget is around £500M (Webb et al., 2009).

BBSRC's report (Webb et al., 2009) on technology transfer within its institutes stresses that it is concerned with technology transfer arrangements rather than wider knowledge transfer arrangements "whilst knowledge transfer includes all mechanisms, networks and relationships that involve scientific knowledge being transferred from one organisation to another, technology transfer is concerned with:

- identification, protection, marketing and conveying of rights to intellectual property often protected by patents or other forms of protection such as trademarks;
- exploitation requiring interaction between inventors and users;
- some kind of commercial return relating to the perceived value of the intellectual property;
- technology transfer organisations (TTOs) being all about facilitating the technology transfer process and adding value."

The current TTO supporting IFR is Plant Bioscience Ltd (PBL). PBL was established in 1994 by John Innes Centre (JIC) and the Gatsby Charitable Foundation for Sainsbury Laboratory as the IP management and commercialisation arm of these research institutes. BBSRC became a shareholder in 2004 when a £2million cash investment was made in return for 33% shareholding in the company. PBL is a commercial 'for profit' company that is now jointly and equally owned by JIC, the Sainsbury Laboratory and BBSRC. BBSRC sponsors several institutes and areas of operations, as summarised in Table 4.

Table 4: BBSRC institutes

Institute	Area of operation
The Institute of Biological, Environmental and Rural Sciences (IBERS)	Sustainable Agriculture and Land Use
Rothamsted Research (RRes) – Rothamsted, Harpenden, Hertfordshire	
John Innes Centre (JIC) – Norwich Research Park	
The Pirbright Institute– Compton, Near Newbury, Berkshire	Animal Health and Welfare
Roslin Institute (RI) – Roslin, Midlothian	
Babraham Institute (BI) – Babraham, Cambridge	Biomedical and Food Sciences
Institute of Food Research (IFR) – Norwich Research Park	
Earlham Institute – Norwich Research Park	Genomics and Bioinformatics

The institutes operate mixed economies where they win research funding from a variety of public and private sector organisations. Research funders such as industry or Government Departments gain much benefit from funding applied research within an institute environment of more fundamental studies. Each institute is an independent company limited by guarantee and a registered charity. This provides independent governance boards, however each institute is subject to a rigorous review every five years through the Institute Assessment Exercise (IAE), which is also in line with RCUK's Pathways to Impact statement.

Changes in public policies and institutional environment have led to a strong encouragement for the commercialisation of scientific findings. Prior to this shift, many scientific findings arose directly from the "ivory tower" of science, without necessarily having a specific aim to utilise or commercialise them. Nowadays, academic research is much more focused on future industrialisation and exploitation of findings, and the impact agenda is a strong driver. There are a number of ways that institutes can achieve impact and demonstrate the contribution that research can make to society and the economy and one of them is through Knowledge Transfer Partnerships (KTPs).

Knowledge Transfer Partnerships (KTPs) are Europe's and the UK's programme scheme with a purpose to help both businesses and science/academia. KTPs' aim is to accelerate business innovation by supporting knowledge exchange with academic institutions. Each KTP is a three-way partnership between a business, an academic institution and a graduate. Each partnership, lasting between 1 and 3 years, employs 1 or more high-calibre KTP Associates (early-career researchers) to work on an innovative project within industry. Associates are jointly supervised by the participating industrial and academic partners. Government support is delivered through a grant to the academic partner. In addition, a contribution from the participating company fully covers an HEI's cost of participation.

KTPs operate through an open call which includes the entirety of BBSRC's remit. BBSRC seeks to promote KTP in industrial sectors that are able to benefit from the UK's excellent bioscience research base and encourages the appointment of KTP Associates at post-doctoral level. As part of a UK-wide programme, these partnerships serve as a mechanism to transfer knowledge and to develop graduate and postgraduate personnel for industrial careers. One of the aims of KTPs is to increase industry's profits and serve as a vehicle to disseminate science and academic knowledge.

3.4 IFR Context

The Institute of Food Research (IFR) is the organisation where the projects in this study were investigated. It will be called Quadram Institute Biosciences (QIB) from April 2017. IFR is considered one of the leading food research institutes in the UK. It is the only institute publicly funded by the Biotechnology and Biological Sciences Research Council (BBSRC) that addresses the fundamental science underpinning food and health operating in the 'post-farmgate' sector of the food supply chain. The institute carries out programmes of basic and applied research and is well networked with academic research centres, universities and institutes, and the food manufacturing and retailing industry, and makes a key contribution to the BBSRC's strategic research priorities of food security, bioscience underpinning health, and bioenergy and industrial biotechnology.

The institute tends to link research on food science, diet and health between universities, institutes and research associations in the UK, Europe and worldwide. IFR is part of the Norwich Research Park (NRP) which includes the University of East Anglia, the John Innes Centre, Earlham Institute, the Sainsbury Laboratory and the Norwich and Norfolk University Hospital which are all located on a single campus in the east of England near Norwich. NRP aims to deliver science focused on the grand challenges of environmental sustainability, food security, food and health, agri-biotech, and med-biotech.

The outputs from IFR contribute to the development of novel foods and manufacturing processes and underpin evidence-based advice on food safety, healthier ageing, disease prevention strategies, and the early detection of risk factors. Policymakers, the National Health Service and specialist services, industry and the public are all end users of IFR research that also stimulates innovation in the commercial sector.

There are several streams of research within IFR, for example, the prevention of the emergence of foodborne pathogens, and a reduction in the present incidence and burden of

food poisoning and gastrointestinal disease. These are underpinned by research at IFR which develops knowledge-led intervention strategies based on an increased understanding of the biology of bacterial foodborne pathogens and the requirements for establishing and maintaining a healthy gut. IFR scientists also investigate the health-promoting nature of plant-based foods through elucidation of the manner by which food components are released from the food matrix in the gut, are absorbed into the body and affect biochemical and physiological processes that promote healthy ageing. Research at IFR also look at colloidal and biopolymeric food architectures to provide knowledge-based approaches for the production of safe and nutritious foods. Another stream is related to biorefinery approaches to maximise the utilisation of agri-food chain co-products and waste, which includes the generation of bioethanol. The institute also houses the National Collection of Yeast Cultures, which is strategically important to the UK in relation to the food production chain.

The institute has a good research infrastructure, with a purpose-built laboratory for work on food-borne pathogens, together with access to several joint technology platforms, a disease modelling unit with gnotobiotic animals, and facilities for human dietary intervention studies. It can be argued that IFR plays a unique role in food and health in the UK and worldwide, operating at both the cutting edge of basic science and applied research.

IFR has also been impacted by the Research Councils' Pathways to Impact statement. Scientists are encouraged to identify and actively engage with different users and stakeholders, propose research that meets their needs and include any evidence of engagement with relevant users and stakeholders, such as food manufacturer SMEs. This engagement can occur in many ways: through knowledge exchange, new products and processes, new companies and job creation, skills development, increasing the effectiveness of public services and policy, enhancing quality of life and health, and international development.

3.5 Conclusion

This section looked at some of the current challenges faced by the food industry, such as food waste (Gustavsson et al., 2011); food security (GECAFS, 2011b, Rayfuse and Weisfelt, 2012, Whipple et al., 2009) and regulatory bottlenecks (CIAA, 2014). It is vital for innovation to flourish and knowledge transfer to be understood so that organisations in this sector can work together to bring about changes and improvements. Besides being a highly regulated sector, the food industry faces the complex situation of being composed mainly of SMEs, and these firms often lack resources to tackle these issues independently. IFR has been chosen as the

research context due to its experience in producing ground-breaking research that aims to address many of these challenges. IFR is a publicly funded research institute, primarily funded by BBSRC, which in turn has its own agenda on how it wants its institutes to work with industry. In order to understand how knowledge transfer works in this context, three projects have been chosen, one driven by health-related concerns, one driven by regulation and one driven by food safety and waste. These projects are briefly described in the Methods chapter and detailed in the Findings chapter. The next chapter describes the philosophical underpinnings of this study, followed by the Methods chapter, where the analytical framework used in this research is explained.

4 RESEARCH PHILOSOPHY

4.1 INTRODUCTION

The purpose of this chapter is to present a broad understanding of different philosophical paradigms and a justification of the chosen philosophical lens for this research. Our understanding of reality (ontology), the nature of knowledge (epistemology) and the aims of the research (axiology) define our standpoint in terms of what we think we can know about a phenomenon. This in turn informs the methodological decisions on how to conduct the research. Table 5 contains definitions for ontology, epistemology, axiology and methodology, based on Lee and Lings (2011).

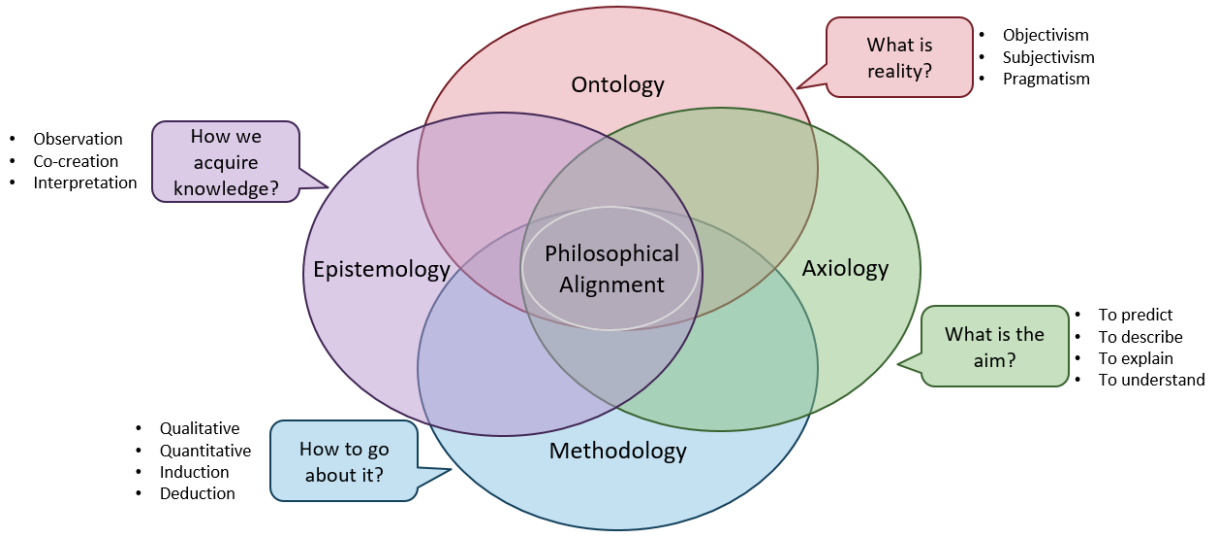
Table 5: Ontology, Epistemology, Axiology and Methodology definitions

Ontology (reality)	The branch of philosophy concerned with the existence and nature of reality. The way we view reality through the assumptions we hold about how the world operates.
Epistemology (knowledge)	The branch of philosophy concerned with how knowledge is acquired and what we can know about it.
Axiology (aim)	The branch of philosophy concerned with values, involving what is worth studying and the aim of the research.
Methodology (tools)	The branch of philosophy concerned on how we go about the research, the tools and techniques of research. This is fundamentally dependent on the previous concepts.

Stemming from the seminal work of Burrell and Morgan (1979), the notions of commensurability and ontology in research practice started to be addressed. However, the dominance of some ontological perspectives as well as epistemological and methodological choices in the broader literatures of innovation management and knowledge transfer and exchange (KTE) seem to have led many academics to follow these conventions without much questioning. Yet different paradigms such as interpretivism, constructionism and critical realism started to emerge, which presented different opportunities for research practice.

It is critical that a researcher's conceptual framework aligns to the researcher's belief system, worldview, research paradigm and methodology as shown in Figure 7. Adopting the lens of critical realism had implications on how this research was conducted, as will be described in the next sections of this chapter. There are a variety of philosophical paradigms in social sciences and some of the key ones will be presented here. The paradigms presented represent both the extreme ends of the philosophical spectrum and the middle ground.

Figure 7: Philosophical Alignment



4.2 ONTOLOGY MATTERS

Ontology refers to the nature of reality. Our conceptual understanding of reality informs us about what we are going to research and what we believe we know about it. As a researcher, it is important to understand how we see reality and how this influences the way we collect data. Table 6 summarises the main three ontological assumptions.

Table 6: Ontological assumptions

Ontology	***Assumptions***
Objectivism	Tangible, single reality Objectivity of reality Reality is divisible and fragmentable
Subjectivism	Multiple realities Subjectivity of reality Socially constructed reality
Pragmatism	Reality is the effect of ideas Reality can be changed through interventions Focus on outcomes

An objective ontology sees the social world as the natural world, made up of law-like, universal patterns that can be used to explain or predict behaviour. These law-like assumptions and generalisability are perceived as good research and data are treated as the gathering of facts. This ontology is directly related to positivist studies that tend to use precise methods that can support research with statistical and objective data. Objectivism offers a clear theoretical focus from the outset and greater control over the research process, however it lacks flexibility and understanding of social processes and people's meanings of social phenomena.

On the opposite side of the spectrum, subjectivism brings a different view, with reality being seen as socially constructed, contextually influenced and subjective. Because there is a focus on meaning, data are treated as a co-creation between the researcher and the participant being interviewed or observed. An implication of this ontology is that it is important to understand a phenomenon from multiple perspectives by capturing different views and experiences. Thus, it is closely linked to interpretivist or constructivist studies where phenomenology, ethnography and more analytical approaches are common. Subjectivism enables the understanding of social phenomena and the understanding of complexity and contextual factors. However, this process of discovery is often very time consuming, uncertain and the analysis process can be challenging and complex.

A pragmatic ontology presupposes that reality is the practical effects of ideas. It is likely to avoid an objective reality and the search for "truth" and uses data as a tool to bring results that will best represent the researcher's value system. This ontology tends to be closely linked to problem solving and mixed methods approaches, design-based and action research.

4.3 EPISTEMOLOGICAL CONSIDERATIONS

Epistemology relates to how we acquire knowledge. Based on assumptions and goals, each paradigm strives toward different types of knowledge, as shown in Table 7.

Table 7: Epistemology

Philosophical Paradigm	***Epistemology***
Positivism	Observation of phenomena Seeks nomothetic knowledge (tendency to generalise) Law-like statements that are generalizable, correlation of variables
Interpretivism	Co-creation and interpretation of phenomena Seeks idiographic knowledge (tendency to specify)
Critical Realism	Observation and interpretation of phenomena Seeks plausible knowledge Knowledge derives from uncovering causal mechanisms
Pragmatism	Seeks valid knowledge Theory and practice are interlinked Meaning and truth are defined in relation to how useful they are in action

Positivism assumes that material and social settings hold regularities or law-like characteristics which provide generalisations both in the basis of explanation and prediction. These regularities allow the formulation of causal statements regarding a sequence of events that is said to explain the other. The basic assumption is that the world is predictable if we are able to find the correlations between cause and effect by seeking nomothetic knowledge that is objective and generalisable. To achieve this type of knowledge, positivism adheres to protocols

that allow accurate and repeatable results. These protocols involve *a priori* identification of a conceptual framework and the variables and hypotheses to be tested. There is an emphasis on keeping separate the researcher and the subject being researched at all times. The main drawback from this perspective is that it fails to answer why events happen, and the constant conjunction of variables does not produce a causal explanation but, simply a statement (Easton, 2010).

Although there are many forms of interpretivism, in general terms it denies of knowing what is real and rejects the possibility of discerning causality, providing only the researcher's own interpretation of a phenomenon. Interpretivism sees language as constituting rather than reflecting reality, reducing all social experiences to linguistic effects which can be eliminated by changing the discursive resources. This paradigm seeks idiographic descriptive knowledge, which Geertz (1973) refers to as "thick description", with the purpose to understand the meaning of the phenomenon under investigation. There is a belief that the world is complex and dynamic, and therefore that it is not possible to identify causal relationships. The research design does not involve a priori statements and tends to evolve as researchers immerse themselves in the changing environment.

Critical realism recognises the fragility of knowledge, with theory being used as a vehicle for delivering explanatory accounts. The nature of knowledge sought is grounded on the people involved in the phenomena under investigation, their opinions and their understanding. This paradigm values both agency and structure to explain a phenomenon and will be explored in more detail in section 4.5.

Pragmatists seek valid knowledge, which is evaluated from the goals that this knowledge is able to support. There is a continuous interaction between knowledge and action so that knowledge is created in and through action and so that the experiences that individuals acquire through action then influence subsequent action.

4.4 AXIOLOGY

Axiology refers to the aims of the research and is closely linked to the researcher's values and goals, as summarised in Table 8.

Table 8: Axiology

Philosophical Paradigm	***Axiology***
Positivism	To explain and predict
Interpretivism	To understand and interpret

Pragmatism	To intervene and change
Critical Realism	To explain and emancipate

Positivist studies seek to explain through general laws and they also seek prediction. A phenomenon is explained and understood if one can demonstrate a systematic association of variables. Accordingly, if one can demonstrate a systematic association then one can also predict the phenomenon.

While some interpretivists do try to identify patterns of behaviour, their central goal is understanding. Understanding involves grasping individual and shared meanings. Interpretivist researchers may state interpretations - their present understanding - however, they view understanding as a never-ending hermeneutical circle. Past interpretations influence current interpretations and current interpretations will influence future interpretations.

Pragmatists are concerned with the uncovering of goals, interests and consequences through the application of interventions and active manipulations. Critical realist research has mainly an emancipatory aim. Emancipation can be achieved in several ways. It can be by shedding light onto something new or different, or it can be by offering an alternative that has not been thought about before. To achieve emancipation, it is important to refer back to the participants and offer them the opportunity to criticise the research findings.

4.5 Critical Realism

Critical realism is a relatively new approach to ontological, epistemological and axiological issues. It combines a realist ontology with an interpretive epistemology (Bhaskar, 1998, Archer, 1995); although a real world exists, our knowledge of it is socially constructed and fallible. Critical realism became influential in a range of disciplines such as economics (Lawson, 1997, Fleetwood, 1999), organisation theory (Tsang and Kwan, 1999, Marsden, 1993), sociology (Archer, 1995), international relations and research methods (Easton, 2010).

The purpose of critical realist studies is not to find generalisable laws nor to give rich description, but to try to unmask the underlying generative mechanisms that are often hidden from our direct experience and are essential to explain how and why social phenomena emerge in a complex and interrelated world.

Similar to objectivism, critical realism's ontology holds that there is one reality "out there" that exists independent of our perception and interpretation of it. Nevertheless, critical realism concedes that reality possesses depth and is an open system that can be interpreted differently

by different individuals (Bhaskar, 1979, Denzin and Lincoln, 1994). Whereas objectivists see the world as a simplistic series of atomistic events and causal regularities which can be observed empirically, critical realists distinguish between several levels of reality: the real, the actual and the empirical.

This approach is also critical in the sense that the social world that we observe comes into being as a result of the interplay between structural and contextual forces and agent's subjective interpretations. Bhaskar (1998) points out that the observer is implicated in the construction of any models they attribute to the behaviours they observe in the world. Thus there is a domain of the 'actual' events happening in the world of the observer, an 'empirical' domain of the observer's experiences, and a 'real' domain of causal processes that may or may not manifest themselves in the 'actual' domain, whether or not these 'actual' events are experienced by the observer.

A critical realist study includes a critical examination of how we conceptualise the objects of our investigation (Sayer, 1992). One of the important contributions such a study can make is that it can 'unmask' potentially 'delusional' conceptualisations. As a result, it does not take actions or events at face value; it searches for the conjunction of perceptions, ideas, intentions and mechanisms that underlie them to understand why such an event happened.

Critical realism diverges from mainstream realism particularly in its opposition to theories such as those of Karl Popper, which offers predictive validity to statements such as 'if a, then b'. Bhaskar (1978) argues that such laws are usually generated in 'closed systems', where other environmental influences can be controlled, and that especially in the social sciences, such systems are neither available nor are the conclusions derived from them generalisable.

4.5.1 ASSUMPTIONS

Sayer (1992, pg.5) sets out what he regards as the 8 key assumptions of critical realism:

1. "The world exists independently of our knowledge of it.

2. Our knowledge of the world is fallible and theory-laden. Concepts of truth and falsity fail to provide a coherent view of the relationship between knowledge and its object. Nevertheless, knowledge is not immune to empirical check and its effectiveness in informing and explaining successful material practice is not mere accident.

3. Knowledge develops neither wholly continuously, as the steady accumulation of facts within a stable conceptual framework, nor discontinuously, through simultaneous and universal changes in concepts.

4. There is necessity in the world; objects - whether natural or social - necessarily have particular powers or ways of acting and particular susceptibilities.

5. The world is differentiated and stratified, consisting not only of events, but objects, including structures, which have powers and liabilities capable of generating events. These structures may be present even where, as in the social world and much of the natural world, they do not generate regular patterns of events.

6. Social phenomena such as actions, texts and institutions are concept dependent. We not only have to explain their production and material effects but to understand, read or interpret what they mean. Although they have to be interpreted by starting from the researcher's own frames of meaning, by and large they exist regardless of researchers' interpretation of them. A qualified version of 1 therefore applies to the social world. In view of 4–6, the methods of social science and natural science have both differences and similarities.

7. Science or the production of any kind of knowledge is a social practice. For better or worse (not just worse) the conditions and social relations of the production of knowledge influence its content. Knowledge is also largely - though not exclusively - linguistic, and the nature of language and the way we communicate are not incidental to what is known and communicated. Awareness of these relationships is vital in evaluating knowledge.

8. Social science must be critical of its object. In order to be able to explain and understand social phenomena we have to evaluate them critically".

4.5.2 CAUSAL POWERS

Entities or causal powers are the cornerstone for critical realist explanation. They can be human, social or material, complex or simple, structured or unstructured, such as organisations, people, attitudes, inventions, ideas, relationships and so on. These causal powers are in contrast to the idea of variables which dominate positivist social science research. Variables are simply the measure of things but not the things themselves (Easton, 2010). "Similarly, the concept of variable that is used in quantitative analysis is an indifferent one as regards causal explanation: variables can only register (quantifiable) change, not its cause" (Sayer, 1992, pg.180).

Realist philosophers of science, such as Bhaskar (1975), Harré and Madden (1975) and Outhwaite (1987)), assume that the natural and social worlds alike do not consist of discrete atomistic events whose regular co-occurrences are the task of scientists to record, but of complex structures existing independently of scientists' knowledge of them. For realists, patterns of events are explained in terms of certain generative mechanisms (or causal powers) which are independent of the events they generate. Generative mechanisms reside in structures and endow them with particular causal capabilities. Generative mechanisms endure even when they are not acting, and act in their normal way even when the consequents of the law-like statements they give rise to are not realised, because of countervailing forces or the operation of other intervening mechanisms.

The term emergence was originally employed in the philosophy of science where it referred to the chemical process whereby the combination of certain molecules produced a new compound which has entirely different characteristics from any of the original molecules. Thus water is a completely different substance from either hydrogen or oxygen. Similarly, Archer argues that the actions of individuals in society produce certain structural features which are emergent; they are more than the sum of the interactions or individuals of which they are comprised (King, 1999, p.206).

Like empiricism, critical realism sustains the importance of observation. However, empiricism recognises these observations take place at the empirical level whilst critical realism offers the idea of a stratified ontology where the domain of the "deep" cannot be reduced to observations at the empirical level.

4.5.3 STRATIFIED ONTOLOGY

For critical realists the social world is ontologically stratified, that is, the social world is irreducible to that which is observed or experienced; and that which is experienced is not fused with actions, as shown in Table 9. The distinction between the empirical (the level of experiences), the actual (the level of events) and the real (the level of structures and causal powers), entails the conception of the world as an open system. This idea of openness and plurality produces a very useful assumption that there is more than one cause producing one effect. What is likely to be happening is a whole range of causes interacting with each other, often in very complex ways, producing a variety of effects in different circumstances.

Table 9: Stratified Ontology

Domain	Entity
Empirical	Experiences and observations
Actual	Events and actions
Real	Mechanisms, structures, rules, norms, regulations, conventions, powers and tendencies

Source: adapted from (Bhaskar, 1978)

The idea is that social structures and human agency exhibit causal powers and that the task of the social scientist is to explore their interaction. Explanation must attend both to structure and to agency, and any explanation which attends to either exclusively is probably going to be inadequate. Social mechanisms and processes operate at different levels of abstraction that tie into each other within a stratified, multilevel and relational model of society. The explanatory pluralism entailed within a realist position has limitations; it cannot admit substantive theoretical approaches to the study of organisation that dissolve structure into agency and consequently remain blind to the structural contextualisation and conditioning of social interaction.

4.5.4 CRITICAL REALISM AND SCIENTIFIC KNOWLEDGE

From a pure empiricist or objectivist ideal, scientific knowledge involves developing and acquiring more sophisticated techniques of observation to guarantee specific "scientific quality", the "truth" of research results. Critics of this paradigm, such as cognitive relativists, claim that there is a complex relation between concepts and reality, which means all knowledge is necessarily socially determined conceptual constructions. A critical realist position bears in mind this criticism and sees knowledge as fallible but not all knowledge as equally fallible. In opposition to cognitive relativist and objectivists, critical realists position is that reality is independent of our knowledge of it, and that science, like all other practices, offers an opportunity to obtain more or less truthful knowledge of this reality. To gain knowledge it is important to understand this reality and its characteristics, not only at the experience and event dimensions, but also the deep dimension where the mechanism that produce these events are located. Scientific observations and facts are therefore, always theory-dependent but not theory-determined.

4.6 CONCLUSION

This chapter has presented the philosophical assumptions underpinning this research and how they affect the subsequent methodological choice and individual methods chosen. In summary, positivists seek the goal of explanation and prediction. A single, immutable social reality exists,

which is fragmentable. They generally seek nomothetic knowledge, assume real causes exist, and adopt a stance of separation between researcher and subject. Conversely, interpretivists seek the goal of understanding. Reality is socially constructed, thus many realities exist. Behaviour cannot be removed from the context in which it occurs because meaning is context-dependent. They generally seek idiographic knowledge, assume real causes cannot be identified, and view the research- informant relationship as interactive and cooperative. Pragmatists are concerned with interventions and seek valid knowledge that is created in and through individual's actions and experiences. Critical realists seek emancipation by uncovering generative mechanisms that will support an explanation of why a phenomenon happens. They do this by going deeper into the "real" level of reality, taking into consideration both individual's interpretations and the contextual elements. Critical realism is the philosophical stance and the approach taken by this research to meet the research aims.

5 METHODS: OPENING UP THE BLACK BOX

"Everything comes from other things and gives rise to other things" David Bohm, physicist

5.1 INTRODUCTION

The methodology determines how the investigation of a particular phenomenon has been approached. Thus, this section will describe the research approach used, the methods for data collection and analysis and how the research was designed in order to answer the central research question and objectives, as summarised in Table 10. As previously stated, critical realism sees the world as an open system, rejecting a standardized toolbox prescription, allowing for a pluralism of approaches for data collection and analysis methods. To find the underlying generative mechanisms for knowledge transfer within the three projects studied for this research, a process-tracing design was chosen to study these individual projects. This chapter provides a description and justification for the design and methods applied in this research. It also includes a brief discussion on the interdisciplinary nature of the concept of mechanism, and a critique of the variable-centred type of research that is inherent in explanatory research.

Table 10: Methods to answer the research question and objectives

Research question and objectives	Method
Research question: How and why knowledge is transferred between a publicly funded food research institute and food manufacturer SMEs in the UK?	Process-tracing design with various types of evidence to develop a mechanismic explanation (Bennet and Checkel, 2015)
Objective 1: To reveal the generative mechanisms that are driving knowledge transfer between IFR and industry to address this sector's challenges.	Analytical framework based on Coleman's boat (Coleman, 1994, Hedstrom and Ylikoski, 2010)
Objective 2: To develop a contextualised explanation of how and why knowledge transfer takes place.	Abductive reasoning and systematic combining (Dubois and Gadde, 2002)

5.2 RESEARCH DESIGN: PROCESS-TRACING

Process-tracing is a within-case method of analysis and a key technique for capturing the presence or absence of generative mechanisms (Bennet and Checkel, 2015). Rohlfing (2013, pg.36) defines process tracing as "a method for the collection of observations in order to be able to reconstruct the process that leads to the outcome of interest". Although the term process-tracing has its origins in the late 1960s in the United States in the field of cognitive

psychology, its usage has been around for thousands of years, dating back from the Greek historian Thucydides. It is ontologically consistent with a mechanism-based understanding of social reality and is methodologically plural. It goes beyond the identification of correlations between independent variables and outcomes with the ambition to trace underlying generative mechanisms that involves interpretation, contextualisation and abstraction by analytically or temporally ordering the empirical data.

Mechanisms are analytical constructs that draw useful connections between social instances (Pouliot, 2014). Causal mechanisms are unobservable; we do not observe causality but make inferences about it, our hypotheses about them generate observable and testable implications. Mechanisms cannot establish causality but they allow explanatory accounts by first utilizing historical or causal narratives and then abstracting the mechanisms. Hedstrom and Ylikoski (2010,pg.51) defined mechanisms as "consisting of entities (with their properties) and the activities that these entities engage in, either by themselves or in concert with other entities. These activities bring about change, and the type of change brought about depends on the properties of the entities and how the entities are organized spatially and temporally."

Process-tracing is an excellent fit with the more interpretivist epistemology of this research, sharing an inductive commitment to fine-grained case studies, focusing on processes and flows rather than static structures and law-like statements (Pouliot, 2014). It could be argued that process-tracing is synonymous with a mechanism-based approach to theory development and not conducive to generalisable theories, which Elster argues as "intermediate between laws and descriptions" (Elster, 2015, pg.45). Because processes and practices are by nature repeated and patterned, it is possible to abstract them from context in the form of mechanisms. These mechanisms are not a cause per se, but theoretical constructs that allow for cross case insights, which are called analytical generality.

In process-tracing it is important to make the practices being investigated explicit. Practices are "socially meaningful and organised patterns of activities; they are ways of doing things…anything that people do in a contextually typical way counts as practice." (Pouliot, 2014, pg.241). Practices are not only the process being investigated that unfolds in time and over time, but also a fundamentally dynamic activity. Practices have causal power as they make things happen, and generative power as they produce concrete effects.

Depending on the context, the same practice of knowledge transfer could produce different effects. For example, the Institute for Food Research's leadership requires researchers to work closely with industry and to produce applicable research. This contextual factor instigates

researchers to work closely with industry. Under a different leadership, the focus could be towards fundamental science, which requires less involvement with industry, and perhaps closer involvement with government. Therefore, the meaning of the practice has to be inferred from the close study and interpretation of the local setting from within the community of practitioners.

There are three different variants of process-tracing – theory-testing, theory-building and explaining-outcome (Beach and Pedersen, 2013). In theory-testing process-tracing, a causal mechanism is hypothesized to be present in a case of a phenomenon. The theorised causal mechanism is then operationalised followed by the collection of empirical evidence, which is then tested to identify if each part of the mechanism is present. Theory-building process-tracing starts with the empirical material and uses a structured analysis of this material to detect a plausible hypothetical causal mechanism. Explaining-outcome process-tracing seeks to craft a minimally sufficient explanation of a puzzling outcome in a specific historical case, being case-centric and following an abductive strategy.

This research will be applying explaining-outcome process-tracing which seeks to build a theoretical explanation from the empirical evidence. The goal is to trace the generative mechanisms that explain knowledge that transferred from the Institute of Food Research (IFR) to food manufacturer SMEs. Process-tracing is always about empirical processes that were realised. In this research, three IFR projects will be individually analysed: one project was health driven (BACCHUS), one safety driven (SUSSLE) and one regulation driven (NIS), as summarised in Table 11.

Table 11: Projects' brief descriptions

Project	Driver	Description
BACCHUS	Food & Health	The main objective of BACCHUS was to understand the cardiovascular benefits from food bioactives, which are compounds found naturally in many different fruits and vegetables. The aim was to develop tools and resources that could be used by food manufacturers to support their health claims.
SUSSLE	Food Safety and Food Waste	The aim of the SUSSLE project was to understand the levels of a bacterium *Clostridium botulinum* in raw food ingredients to help the food industry deliver safe chilled foods more sustainably, by extending shelf-live and reducing waste.

NIS	Food Regulation	The aim of NIS was to provide a cost-effective nutritional labelling service to food SMEs by offering calculations based on IFR's Food Databanks. A new regulation states that all food producers must provide a nutritional label from December 2016.

The main goal of explaining-outcome process-tracing is to depart from data to develop a middle range explanatory theory that is neither true nor false, but useful in making sense of the messy process of knowledge transfer. During this process, induction, interpretation and abstraction are mutually reinforcing operations. Therefore, the main objectives are: (1) to capture the generative links (mechanisms) of knowledge transfer and (2) to produce analytical general insights.

5.3 Research Procedures

The research procedure aims to show an overview of the step by step data collection and analysis of this research, as summarised in Table 12. It offers a guideline to follow the rationale of how the research evolved from initial fieldwork preparation to the final follow up visit.

Table 12: Research procedure

1	Initial contact preparation	Before contacting individuals, there was an investigation to identify research leaders at IFR that undertook projects with industry. This investigation was done through reading reports such as the Brookdale Report (Brookdale, 2013) that identifies impact cases from the institute; and interviewing the institute's director and other senior members at IFR that had a strategic view and knowledge on various projects.
2	Initial contact	Initial contact with the identified research leaders was via email, where there was an introduction to this research project and interviews were arranged.
3	Observations	Attendance, observation and discussions were conducted in sixteen events, including networking, seminars and conferences. These started from the very beginning of the study and ran until the end of fieldwork. The purpose of attending these events was to gather information regarding challenges affecting the food industry and to network with various prominent figures in the sector.
4	First-round interviews	Twenty-one semi-structured interviews were undertaken with a variety of research leaders where several potential projects were identified. During these interviews, open exploratory questions were asked, such as "tell me about different projects where there was knowledge transferred and exchanged with industry", "what kind of projects you do and why". During these initial interviews, accessibility to further information, documentation and other involved stakeholders was assessed. This phase also included interviews with some key players in the wider environment surrounding IFR such as their main funder, (the BBSRC),

		technology transfer intermediaries, contract lawyers and the largest food retailers.
5	Case Selection	The projects were chosen on the basis of their purpose, variety, evidence, presence of industry collaboration and accessibility (please see 5.4 Case selection for a full description of criteria).
6	Analytical Framework	The analytical framework was developed from a long search for an appropriate way to capture mechanisms to eventually produce an explanation. It comprises of three main levels: structure, agency and interaction. To understand these levels, interview questions for the second round were formulated around each of the levels.
7	Documents	An assessment and collection of data was undertaken on IFR's and the projects' webpages, contract agreements, description of work documents, projects' funding calls, reports and papers on projects' dissemination, annual reports, corporate brochures, newsletters, projects' leaflets and posters, and consortium agreements.
	Second-round Interviews	This round was focused on more specific questions that refer back to the analytical framework and included thirty-one interviews. For example, to find out more about structural elements such as norms and resources, questions were asked such as how they came across the project, and what hindered and what helped the development of the project. To find out about their motivations (agency), questions were asked such as why they got involved in the project, and what kind of outcome they expected. An example of questions asked to the interviewees can be found in Appendix 2. Lastly to understand how different individuals interact in the project, questions were asked such as how decisions were made, and how results were disseminated. During the interviews with research leaders at IFR, industry partner contacts were collected and also any further available documentation regarding the project. Interviews with the industrial partners involved in the projects were also conducted and similar questions were asked.
8	Transcriptions	Interviews were transcribed verbatim.
9	Coding	Transcriptions and documents were coded according to the analytical framework, as described in section 5.8.2. These macro-codes formed a guideline structure to assist the interpretation of the findings.
10	Analysis	Qualitative analysis was used from data sources from documents and interviews and categorised into the macro codes for each project. Abductive reasoning and systematic combining were then used as the analytical methods to abstract the generative mechanism and match corresponding theoretical explanations.

5.4 Case Selection

Process-tracing methodology requires careful selection of cases, and it is important to make the case that is being investigated explicit. Contextual and structural elements within the empirical findings are case specific. On the other hand, the analytical level of the mechanisms can potentially be generalised to a larger class of cases, allowing for cross-case insights. The search for analytical generalisation is not the same as for empirical generalisation, and

theorising means abstracting away from the empirics to reach a conceptual level that makes cross-case comparison possible in the future.

To select the cases, the following criteria were used:

1) Purpose: the project has to intentionally aim at transferring knowledge, related to the broader area of food and health, from academia (research institutes, university) to industry (food manufacturers, retailers). This research explicitly focuses on one-way transfer of knowledge, while recognizing its ample multidirectional exchange. This is an important condition for future comparative work on identifying mechanisms for knowledge transfer.
2) Variety: in order to establish similarities and differences among mechanisms for knowledge transfer, different types of projects should be chosen.
3) Evidence: there must be evidence that the knowledge has been transferred and is being used by industry. This was confirmed by interviews with industry and wider reports and guidelines.
4) Presence of industry: the project must have a direct impact to at least one industry partner that is contactable by the researcher. This has been achieved for all 3 projects and phone interviews were conducted with food manufacturers, food retailers, and government bodies.
5) Accessibility: the project must allow ease of access to data, information and interviewees willing to share their knowledge of the project to allow in-depth process-tracing analysis. I established a close relationship with IFR in general, having had a co-supervisor based there for the first 2 years of my research (until his retirement), which facilitated access to people and data.

Each project was selected with these criteria which can be illustrated in Table 13 below:

Table 13: Project criteria

	BACCHUS	SUSSLE	NIS
1) Purpose	To transfer knowledge related to bioactives and peptides from IFR science base to food manufacturers.	To transfer knowledge related to assessment of food poisoning bacteria *C. Botulinum* in chilled foods, consequently extending shelf-live and reducing waste.	To transfer knowledge to food producers related to the nutritional composition and labelling of their foods.
2) Variety	Food and health	Food safety	Food regulation
3) Evidence	Food manufacturers were able to use	Food manufacturers were able to significantly reduce	Small and medium food producers were able to

	findings from the project to back their products' health claims.	their waste by increasing shelf-live and reducing *C. Botulinum* levels.	comply to new nutritional labelling regulation by accessing an affordable and efficient service.
4) Presence of industry	This project had a direct impact on 16 food manufacturers and several food manufactures were indirectly benefited.	This project had a direct impact on 3 food manufacturers and over 200 food manufactures were indirectly benefited.	This project had an impact on over 250 food producers so far (September 2016).
5) Accessibility	Project leader agreed to be part of the study; interviews were established with IFR scientists and food manufacturers involved in the project.	Project leader agreed to be part of the study; interviews were established with IFR scientists and food manufacturers involved in the project.	Project leader agreed to be part of the study; interviews were established with IFR scientists and food producers involved in the project.

Other projects at IFR such as ComBase, Ovatus, Super Broccoli, Chicken Campylobacter, Model Gut, Biorefinery and National Collection of Yeast Cultures (NCYC) were considered but SUSSLE, BACCHUS and NIS met the criteria more closely. Unsuccessful projects not only did not meet all of the criteria but also did not qualify for process-tracing analysis due to not being fully realised, therefore were not pursued for further investigation.

5.5 Quality Procedures

The following Table 14, adapted from Symon and Cassell (2012), indicates the procedures that were taken in order to enhance the quality of the research and the definitions for each criterion.

Ontological appropriateness: achieving suitability between research question, conceptualisations and worldview of a stratified reality.

Credibility: achieving fit between the constructed realities of research participants and researcher's interpretations, including dealing with biases.

Transferability: providing sufficient detail about the research situation so readers can judge to which other context the findings are relevant.

Dependability: providing an audit process that tracks and accounts for changes in the methodological process followed.

Confirmability: grounding the conclusions in data by showing where the data came from (data collection) and how they were transformed into findings (data analysis).

Table 14: Quality criteria and procedures

Criterion	Key concern	Tactic	Procedure
Ontological appropriateness	Characteristics of the research problem.	Selection of the research problem, phenomenon, case and questions.	This was done by inductively researching a worthy problem and cases that would contribute to academic knowledge and practical use. This is summarised in the Introduction chapter.
Credibility	Mechanism construction	Reflexivity. Bayesian logic.	Researcher kept diary and constant reflection on hers and participants' behaviours, actions and assumptions. This is summarised in the Introduction chapter: Researchers' Reflexivity. Accrediting or discounting evidence from individuals with potential instrumental goals for providing, distorting, or hiding evidence. Thus, different individuals and documents were selected and analysed for each project, and consideration to context and authorship in assessing evidence.
Transferability	Generalisability	Mechanisms are generalisable but not findings (generalisability of causal mechanisms rather than inputs/outputs). Contextualised explanation.	The mechanisms abstracted in the projects may be found in similar settings, for example, other science-industry relationships. A contextualised explanation is offered by taking into account different levels of analysis. This criterion is summarised in the Conclusion chapter.
Dependability	Reliability	Develop rigorous database.	Create rigorous audit trail and findings table.
Confirmability	Quality of conceptualisation	Use multiple sources of evidence and informants. Detailed descriptions of data collection and analysis procedures (transparency).	Different individuals and documents were selected and analysed for each project. See Methods chapter.

5.6 Gathering the Evidence – Data Collection

Primary data were collected from fifty-two in-depth interviews with research leaders and scientists from IFR, participants from food manufactures, and from government organisations that were part of the projects, as summarised in Table 15. These individuals formed the "causal group" that informed the investigation on how and why knowledge transfer occurred. The

causal group is the interconnected network that has co-produced the social phenomenon to be investigated. Participants have been progressively identified through snowballing from previous interviews. Evidence was also collected from observations and documentation, both public and confidential, including research contracts, transfer agreements, proposals for collaborative research, and live and archived websites.

Table 15: List of interviewees

Interview	Participant	Position	Organisation
1	Participant 1	Head of Ethical and Sustainable Sourcing	ASDA
2	Participant 2	Head of Quality, Safety & Supplier Performance	Sainsburys
3	Participant 3	Food Waste Reduction, Group Corporate Responsibility	Tesco
4	Participant 4	Climate change and sustainability	Tesco
5	Participant 5	Head of Quality	Waitrose
6	Participant 6	Company Nutritionist	Marks & Spencer
7	Participant 7	Head of International Office	IFR
8	Participant 8	Research Leader	IFR
9	Participant 9	Head of Extra Operations	IFR
10	Participant 10	Research Leader	IFR
11	Participant 11	Lawyer	NBI
12	Participant 12	Project Manager	NBI
13	Participant 13	Research Leader	IFR
14	Participant 14	Senior Scientist	IFR
15	Participant 15	Senior Scientist	IFR
16	Participant 16	Commercial Director	IFR
17	Participant 7	Head of International Office	IFR
18	Participant 17	BBSRC Council Member - academic	BBSRC
19	Participant 18	BBSRC Head of Business Interaction	BBSRC
20	Participant 19	FSA Head of Science Delivery	FSA
21	Participant 20	BBSRC Executive Director, Innovation & Skills	BBSRC
22	Participant 21	Research Leader	IFR
23	Participant 22	Research Leader	IFR
24	Participant 23	Research Leader	IFR
25	Participant 24	Research Leader	IFR
26	Participant 25	Research Leader	IFR
27	Participant 26	Research Leader	IFR
28	Participant 23	Research Leader	IFR
29	Participant 27	SME	Crème Global
30	Participant 13	Research Leader	IFR
31	Participant 28	Senior Scientist	IFR

32	Participant 8	Research Leader	IFR
33	Participant 29	Business Development Manager	IFR
34	Participant 30	CFA Director	Chilled Food Association
35	Participant 26	Research Leader	IFR
36	Participant 31	SME	Critical Processes
37	Participant 32	SME	Kamut
38	Participant 33	SME	Prodigest
39	Participant 34	SME	Greencore
40	Participant 35	Director	Commonwealth Scientific and Industrial Research Organisation (CSIRO)
41	Participant 36	SME	Chillies Galore
42	Participant 37	Unilever	Unilever
43	Participant 38	SME	Alburgh Ice Creams
44	Participant 39	SME	PD Artisan
45	Participant 16	Commercial Director	IFR
46	Participant 40	SME	ADDO
47	Participant 41	SME	Admira
48	Participant 42	SME	Nutrika
49	Participant 29	Business Development Manager	IFR
50	Participant 43	Associate Director, Knowledge Exchange & Commercialisation	BBSRC
51	Participant 8	Research Leader	IFR
52	Participant 26	Research Leader	IFR

Field work notes were taken at the events including presentations, facts and figures, and key discussions. These were used as part of the data analysis. This evidence from interviews and documents provided a narrative account of events, patterns and themes. From these narrative accounts, generative mechanisms were abstracted and a reinterpretation and analysis of these mechanisms began. The analysis, interpretation and theorisation of this research was done through abductive reasoning and systematic combining to abstract generative mechanisms.

Within a process-tracing design, an array of data collection methods or evidence collection is acceptable. The most reliable type of evidence is objective and unbiased. As we are studying participants' experiences and observation, biases will always be a detriment. However, subjectivity can be mitigated by triangulating the data with different participants and documents. Alternative methods to collect evidence such as observations and dairies were also considered. However, time constraints and unavailability of participants created an obstacle for these methods. As process-tracing is a qualitative within-case tool, alternative

methods such as surveys would not give the in-depth level of access and understanding for each individual case and were therefore rejected as unsuitable to answer the research question.

5.6.1 ETHICS AND CONSENT

An ethics form is compulsory to be signed before fieldwork commences which was acquired and approved by the Norwich Business School and Postgraduate Research Office at the University of East Anglia. A research ethics form together with a fieldwork risk assessment form were approved and submitted before fieldwork started. Before the interviews and collection of documents with sensitive information, a consent to digitally record and transcribe all interviews was verbally agreed with the participants. The purpose of the study was communicated both by a written email and verbally, and participants were allowed to withdraw any information to maintain confidentiality and anonymity. The information regarding the projects are publicly available and the participants agreed they can be used and referenced in this thesis using the projects' real names.

5.6.2 INTERVIEWS

Interviews are defined as "social encounters where speakers collaborate in producing retrospective (and prospective) accounts or versions of their past (or future) actions, experiences, feelings and thoughts" (Rapley, 2004, pg.16). Structured interviews are usually associated with quantitative research, where sequences of questions and their wording are predetermined and do not change during the interview process. These surveys mainly contain closed or multiple-choice questions covering a specific topic and thus give respondents only limited space to express their viewpoint (Fontana and Frey, 2000).

Qualitative or in-depth interviews, in contrast, are both terms used to describe unstructured and semi-structured interviews, and are one of the most common methods applied in qualitative research intended to obtain interpretations and 'thick' descriptions, i.e. rich and elaborate responses from participants (Rapley, 2004). Unstructured interviews comprise often informal 'conversations' without following a set of predetermined questions, thus allowing respondents room to focus on the issues they consider relevant for the particular topic under investigation (Fontana and Frey, 2000).

Semi-structured interviews are positioned between standardised and unstructured interviews on the rigidity scale. Based on a list of questions, also called the interview guide, they ensure that specific topics are covered while simultaneously being flexible in that the sequence of

questions is variable and queries can be added or omitted depending on the course of the interview and the issues addressed. In that sense, the researcher tries to "fit their pre-defined interests into the unfolding topics being discussed, rather than forcing the interviewees to fit their ideas into the interviewer's predefined question order" (Gibson and Brown, 2009, pg.88). This process enables participants to express their points of view, but also allows comparisons to be drawn across interviews during data analysis (Fontana and Frey, 2000).

This research has employed semi-structured questions because they were the most appropriate to give space for the participant to express their experiences and their own views. During the first-round interviews, which were more exploratory in nature, very open questions were asked so that the participant could discuss issues freely and to build rapport between the interviewer and interviewee. This technique was very helpful when the second round of interviews came. These interviews were also semi-structured, however the questions were more directed to answer specific questions about the project, containing questions that would provide information for the research framework and the generative mechanisms involved.

The interviews started with research leaders from IFR, to whom sociometric questions were asked: To whom did they most often turn for external projects? Who were the other colleagues that participated in the project? In response to these questions, names of these colleagues and external partners were requested, which made it possible to connect with the rest of the stakeholders engaged on each project. This snowballing technique facilitated the named persons to be included in the sample.

Primary data for the research were gathered through two rounds of semi-structured interviews, each lasting between 30-90 minutes, with key stakeholders from IFR involved in the project, as well as participants from the wider environment. During the first round, general questions regarding projects with industry were asked on topics such as how projects are initiated, why they work with industry, what kind of network is in place, how they share knowledge and the impact of the wider environment and leadership on knowledge transfer.

In the second round, more specific questions were asked, such as how the project came about, what was their role and responsibility in the project, why they got involved, what were their objectives for taking part, how were decisions taken. These questions were focused on the analytical framework and a sample list of questions is give in Appendix 2. Stakeholders outside IFR that were involved in the project, including industry partners, were also interviewed. The interview data were triangulated between interviews with different participants, and the various documents and observations.

5.6.3 OBSERVATIONS

Attendance, observation and discussions were conducted in sixteen events, including networking, seminars and conferences. The purpose of attending these events was twofold. Firstly, the events provided current information regarding challenges affecting the food industry in general. Secondly, they provided a platform to network with various actors and established contacts that were later used for interviews or obtaining access to documents and reports. They also provided an opportunity to discuss issues around innovation and knowledge transfer with the most prominent figures in the sector. A list of events attended is summarised in Table 16.

Observations focused on problem-solving discussions and talks, where the interaction and opinions of different actors could be captured. They attempted to record information about (a) what are the challenges occurring in the food industry during the period of this study, including backgrounds, processes, and outcomes; (b) how are solutions proposed for current challenges; (c) which processes facilitate and inhibit innovation and knowledge transfer; (d) what are the characteristics of different actors and an understanding of power dynamics (e.g. BBSRC x IFR x food manufacturers; complex or simple, ambiguous or clear).

Table 16: List of events attended

Event	Details	Date	Duration
Food Security and sustainability	Seminar UEA	14 November 2013	2h
Natural capital and agricultural intensification: can we have both?	Seminar John Innes Centre	28 November 2013	3h
How do you make crisps sustainable?	Seminar UEA	22 November 2013	4h
Food security: is the answer sustainable intensification?	Seminar John Innes Centre	02 December 2013	2h
Priority Research Questions for the UK Food System	Seminar The Royal Society	03 February 2014	3h
NRP Knowledge and Innovation Community (KIC) in Food	Bid proposal meetings and discussions IFR	Various 2014-15	40h
Project SCALE - Improving the Food Supply Chain	Conference Cranfield University	19 March 2014	7h
Food and Drink Federation (FDF) Unlocking Innovation in the UK Food and Drink Manufacturing Industry	Networking event London	20 March 2014	4h

Institute of Food Science and Technology (IFST) Conference	Conference London	14-15 May 2014	16h
Norfolk Network Talk - East of England Agri-Tech cluster	Networking event Norwich Forum	22 May 2014	3h
IFST Reception	Networking event House of Lords	02 July 2014	2h
What are your individual nutritional needs?	Seminar/networking Assembly House	25 September 2014	2h
Lincolnshire-New Anglia LEP-Industry Forum	Forum IFR	13-14 October 2014	10h
Total Food	Conference John Innes Centre	11-13 November 2014	15h
Food Matters Live	Conference/exhibition Excel, London	18-19 November 2014	15h
Institute of Food Science and Technology (IFST) Conference	Conference Imperial College London	23 April 2015	8h

5.6.4 DOCUMENTS

Documents can give an overview of what goes on in an organisation to help uncover things such as its culture and ethos (Bryman, 2012). Atkinson and Coffey (2011) argued that documents should be recognised for what they are supposed to accomplish and who they are written for, and not a simple reflection of an organisation's reality. This ontological view of documents suggests that they should be examined in terms of the context in which they were produced and their implied readership (Bryman, 2012).

Documents from a wide range of sources were used as evidence. These included official documents from IFR such as project contracts, terms of agreements, leaflets, and so on. Other documents from mass-media outputs such as magazines, newspapers, internet resources and archived documents were also accessed. Data sources such as official websites, background documents and publicly available reports, interviews and articles were also used to extend the findings. Using the different data sources as a starting point, the analysis revealed different mechanisms operating in the project, as will be described in the findings chapter. A full list of documents is summarised in Table 17.

The documents added context, and gave further information that could be utilised during the face-to-face interviews, provided contact detail information, and confirmation that the industry

and government are utilising the knowledge from IFR, including their results and findings. The documents also gave an indication of the scope of reach that their projects had, not only to the immediate stakeholders involved but also to the wider industry (e.g. food retailers, government advice, food manufacturers, and so on).

Table 17: List of documents analysed

Document	Organisation	Project
Science & Innovation Report 2014	BBSRC	All
Delivery Plan 2014-15-16	BBSRC	All
Institute Assessment Exercise Outcomes 2011	BBSRC	All
Business Interaction Strategy	BBSRC	All
BBSRC Institutes: Technology Transfer Review 2009	BBSRC	All
Review of the Institute of Food Research science and future governance 2007	BBSRC	All
Annual Report and Accounts 2013-14	BBSRC	All
Impact of the Institute of the Food Research	Brookdale Consulting	All
Annual Report and financial statements	IFR	All
Consortium Agreement	IFR	BACCHUS
Call FP7-KBBE 2012	European Commission	BACCHUS
Guide for applicants – call identifier FP7-2012-KBBE-6-singlestage	European Commission	BACCHUS
Guide to creating a front of pack (FoP) nutrition label for pre-packed products sold through retail outlets	Food Standards Agency	NIS
Project PID	IFR	NIS
Project Report	IFR	NIS
Farming and Food Science LINK Programmes	DEFRA	SUSSLE
Final Project Report	IFR	SUSSLE

5.7 MECHANISMS

A mechanism based approach has an explanatory purpose to explain an observed relationship or event. Unlike a regression that tells us about the relationship between variables, a mechanism explanation enables us to move beyond thinking in terms of variables to considering the bigger picture of action in its entirety by making explicit the mechanisms. Mechanisms are described using verbs and causal links rather than nouns and variables.

In the social sciences, one of the first authors to discuss the concept of mechanism was sociologist Robert Merton (Merton, 1967), who rejected the attempt to develop general sociological theories, and instead promoted the search for a middle ground between social

laws and descriptions, advocating that mechanisms constitute such middle ground. He defined social mechanisms as “processes having designated consequences for designated parts of the social structure” (Merton, 1967,pg.43) and our task is to identify such mechanisms, how they come into being, and why they operate effectively or fail to emerge.

Mechanisms are analytical constructs whose objective is to draw useful connections between instances and from these connections develop explanations. Unlike a probabilistic or deterministic explanation of regularity and covariation approaches, a mechanismic explanation focuses on the generative component of causal argumentation. A phenomenon observed through empirical patterns of covariation (between X and Y), either probabilistically or deterministically, is associated with the deductive-nomological model used by positivists. A recent turn towards a mechanism-centred view and a greater focus on getting “inside the box” of causation has embraced a wider range of researchers such as interpretivists, case-study researchers, experimentalists, modellers, and behaviouralists.

Mechanisms by themselves do not cause outcomes to occur, but the interaction between mechanisms do. They are ontologically different from variables that measure attributes of specific cases; mechanisms uncover the underlying process that produces outcomes. Mechanisms operate at an analytical level below that of a more encompassing theory; they increase the theory’s credibility by rendering more fine-grained explanations (Johnson, 2002). The process of looking for these underlying mechanisms involves constantly looking for connections or patterns in a series of mini-checks within the evidence gathered, analysing and interpreting them.

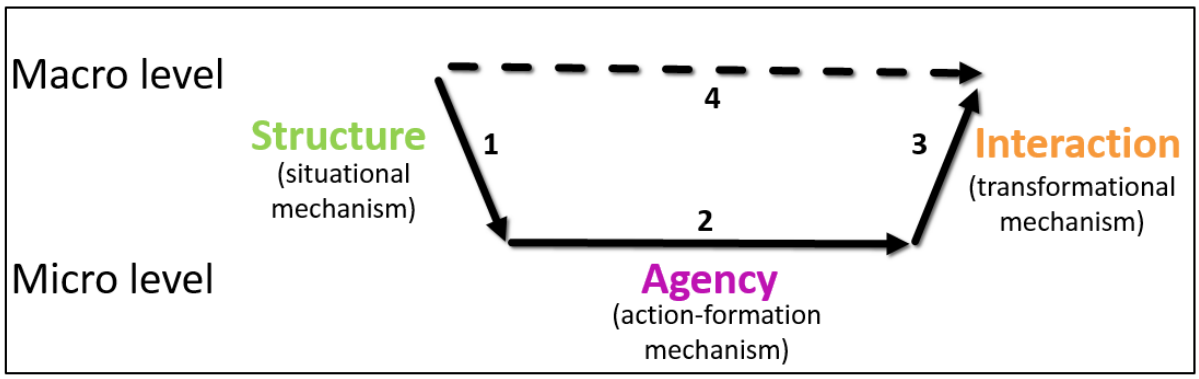
Philosophical discussions about the role of causation and dissatisfaction onto its assumptions in deductive and covariational reasoning (that underlie positivist approaches) have led to the re-surfaced stream of thought based on social mechanisms. The ideas behind the mechanismic view in the social sciences draw from political science (Falleti and Lynch, 2009), analytical sociology (Hedstrom and Ylikoski, 2010) and middle-range theory (Pawson, 2000). The knowledge transfer literature has generally taken a covariational or relational view, therefore lacking a mechanismic perspective.

5.7.1 PURPOSE OF MECHANISMIC VIEW

In innovation and knowledge transfer literatures, the aim usually is to explain either a macro-level phenomenon (located in the upper right hand corner of Figure 8), such as an organizational-level outcome, or a link between macro phenomena, as indicated by arrow 4. An example of the former could be an explanation of how food manufacturers attract venture

capital by becoming greener and focusing on reducing waste. To explain their financial performance, for example, researchers look at variables such as the application of reduced carbon emissions and recyclable packaging as variables that affect their performance.

Figure 8: Analytical Framework



A mechanismic explanation advocates that there is no mechanism that operates solely at the macro level. In other words, there are no macro-level entities that possess the capacity to act or the capability of producing outcomes, hence the importance of looking at individual actions. However, that is not to say that macro-level explanations are not important. They are very relevant to establish correlations between macro-variables and are a useful shorthand, however they need further explanation at the micro-level. A mechanismic explanation takes the position that a macro phenomenon such as knowledge transfer in a science-industry setting must ultimately be grounded in explanatory mechanisms that involve individual actions and interactions.

Mechanism-based explanations aim to provide a plausible account of the generative mechanisms that are necessary to explain how, under certain contextual conditions, an observed phenomenon has emerged. This perspective aims to identify the generative mechanisms that allow us to explain with some confidence ‘‘how’’ and ‘‘why’’ something happened rather than merely observing that something happened (Rohlfing, 2013).

An emphasis on causal mechanisms implies that knowledge transfer in a public funded research institute should be concerned with how intentional human action and interaction produce the phenomenon of knowledge transfer. Opening up the black box is therefore important. Black boxes may sometimes be justified in terms of explanatory parsimony (Hedstrom and Ylikoski, 2010) as indeed happens in arrow 4-type explanations.

The main point of a mechanismic explanation is that a macro-level explanation is not satisfactory and a deeper understanding of the mechanisms that generate the macro-level observations is necessary. According to Bhaskar (1998), a mechanism is a term that designates something real and independent of patterns or events generated. These mechanisms only operate if triggered, therefore they endure and are present even if they do not manifest. However, under certain conditions, they generate a series of events.

A mechanism-based perspective has been adopted in this study to explain the knowledge transferred between a publicly funded food research institute and food manufacturers in the UK. Through process-tracing, three projects have been investigated.

5.7.2 TAKING ON EQUIFINALITY

Process-tracing forces the researcher to take equifinality into account, that is, to consider alternative explanations within a single case. This is because different conditions or sets of conditions can lead to the same outcome. The most critical problem with a mechanismic explanation that takes into account micro and macro level considerations, is that a macro-level explanation is likely to have many alternative micro-level explanations which cannot be rejected. Even if a large sample can be constructed, a problem of alternative explanations may persist. This research will look at the most plausible explanation for each individual project with predominant mechanisms, however alternative, less prominent mechanisms are also suggested.

5.8 DATA ANALYSIS

Content analysis is considered to be one of the most important research methods in the social sciences, and defined as a “technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use” (Krippendorff, 2004, pg.18). In reaction to critiques that dismissed the originally largely quantitative method as overly simplistic reductions of data, researchers developed a qualitative content analysis approach that adheres to the systematic nature of the original technique, but avoids unnecessary or precipitant quantifications (Mayring, 2004).The aim is to achieve a summarised portrayal of a phenomenon by closely examining and distilling considerable amounts of text into relevant contextual categories.

Qualitative content analysis is therefore defined as “a research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns” (Hsiu-Fang and Shannon, 2005, pg.1278). It is not only

concerned with gaining insight into the meaning of communication, but also with identifying critical processes.

5.8.1 TRANSCRIPTIONS

Both face-to-face and telephone interviews were digitally recorded with the consent from the participants. Verbatim transcriptions were made of all 52 interviews. As the verbal content of the transcriptions was the most important, intonations, pauses, and so on, were not included.

5.8.2 CODING AND SYSTEM FOR REPRESENTING THE DATA

At the beginning of the analysis process NVivo 10 software was used to assist in data management in terms of classification and organisation. As the second round of interviews moved forward, the questions began to become tailored to each interviewee and NVivo 10 was not then used to classify data, but simply as a storage facility. Therefore, a decision was made to use a manual coding technique as it was more suitable to capture the nuances from the transcripts. The analysis of documents provided further information regarding the narratives presented in the interviews. Notes from the observations provided an overview of the knowledge transfer landscape in the food industry.

The data analysis from the transcriptions and documentation was started by coding sentences and quotes that were directly representative of the framework. The framework is divided into three parts: structure, agency and interaction. The evidence was organised into macro-codes for each level of the framework, as shown in Table 18:

Table 18: Macro Codes

Macro Codes for Structure Level	Macro Codes for Agency Level	Macro Codes for Interaction Level
• Rules • Norms • Resources	• Motivations • Beliefs	• Interactions • Actions

Each of these macro codes are explained in the section that follows. An example of an interview excerpt with a highlighted macro code is exemplified in Appendix 3.

5.8.2.1 Structure

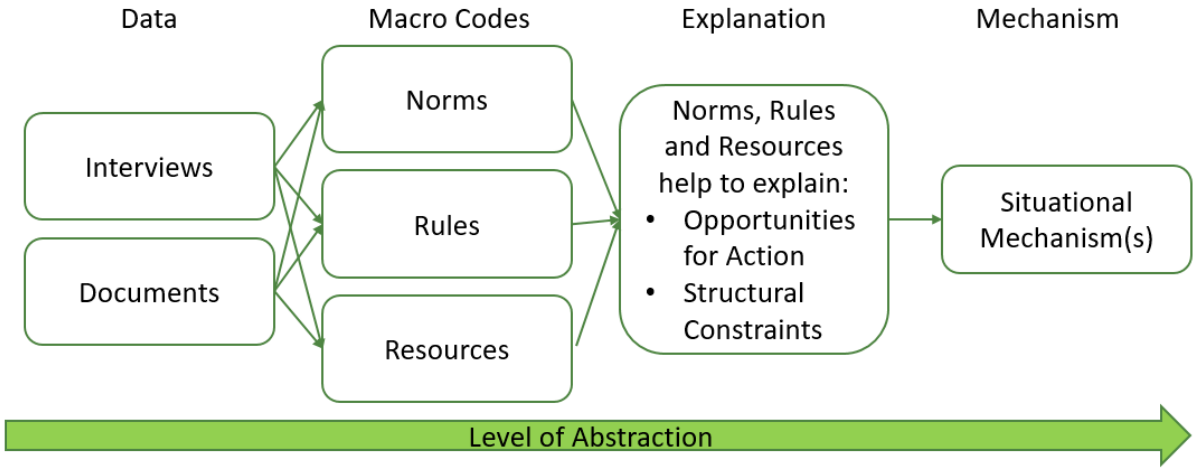
The structure level represents IFR's own and the wider environment's rules, norms and resources. These macro codes were used to help identify the structural constraints and opportunities for action. For example, due to a limited amount of internal funding (resources),

research leaders must seek external funding streams (structural constraint); having worked with food manufacturers before (resource), there is already a network of contacts in place to put a consortium together (opportunity for action). A definition of these structural elements can be found in Table 19 with a representation in Figure 9.

Table 19: Elements of structure level definitions

Macro Codes for Structure Level	
	How macro-level structure affects individuals
Rules	A rule is a set of explicit instructions, regulations or procedures that state the way things are or should be done, and tells individuals what they are allowed or are not allowed to do. Each organisation makes up its own rules and decides when those rules have been violated and what to do about it. They are usually issued by top or middle management and follow the direction compatible with strategic organisational goals, however they sometimes evolve autonomously of management's strategy. Rules provide detailed guidance about how a strategy can be translated to action. Examples: contractual agreements, ethics code, organisational structure, how information flows, codes of conduct, legislation, funding rules, and so on.
Norms	A norm is a guideline or an expectation that guides behaviour. Norms change according to the institutional environment or situation and constantly change or are modified over time. They can be formal or informal (unspoken or unwritten), implicit or explicit. A norm gives a person a rule of thumb for how they should (and should not) behave. Examples: the way researchers are expected (or not) to attract external funding, to work with industry, to engage with various disseminations routes, to publish in renowned journals, to have an impact agenda, and so on.
Resources	A resource is a useful or valuable possession such as money, staff, physical facilities, equipment, skills, and so on. Examples: lab facilities, science experts, available funding, contacts network, reputation, and so on.

Figure 9: Structure level: from data to mechanism



5.8.2.2 Agency

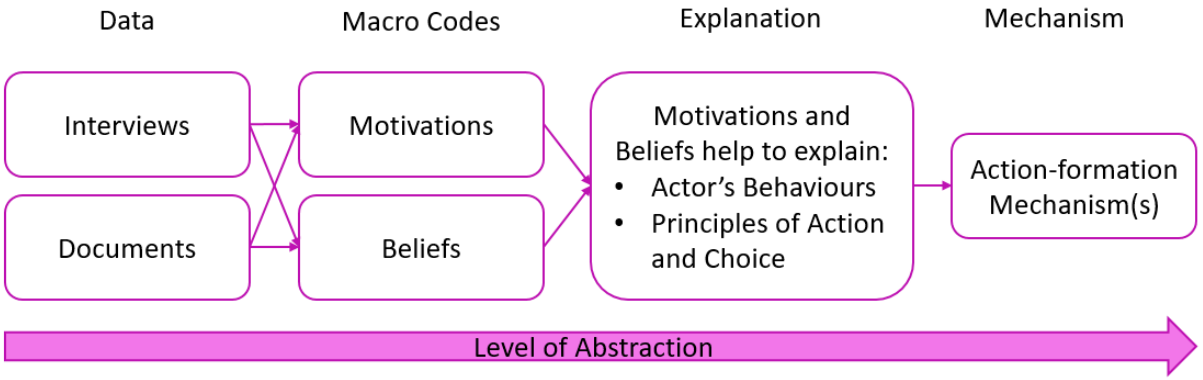
The agency level represents research leaders' motivations and beliefs. These different individual's characteristics – motivations and beliefs – help to explain actor's behaviours and principles of action and choice. Behaviours are the ways in which individuals act and conduct themselves. For example, given the structural conditions and the individual desire to work with industry (motivation), the individual behaves in a rational or rule-following way (explaining behaviour); having the motivation to do more fundamental research (motivation), individuals choose to look for project opportunities that will allow the development of their own research (explaining principles of action and choice). A definition of these agency elements can be find in Table 20 with a representation in Figure 10.

Table 20: Elements of agency level definitions

Macro Codes for Agency Level	
How individuals act given their motives and situations	
Motivations	Motivations are reasons for acting in a particular way. They represent the desires and needs as to why individuals act. Examples: to do more research, to add value, to tap into new technologies, to be recognised, to be promoted, to get more funding, to have status, to have access to new jobs, opportunities, to improve their profile and that of their research group, to be a "good" employee, and so on.
Beliefs	Beliefs are opinions or convictions that something or a situation is reasonable or true. They are closely related to individual's values and can affect relationships at work. Beliefs tend to govern individual's experiences and reflect who they are and how they live their lives.

	Examples: recognising own skills and expertise, commitment, assumptions and so on.

Figure 10: Agency level: from data to mechanism



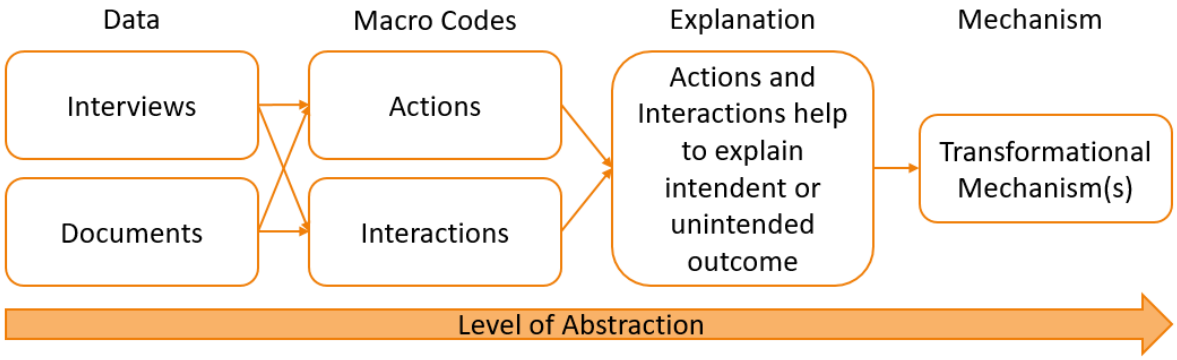
5.8.2.3 Interaction

The interaction level represents individual's actions and interactions. At this level, research leaders and other project stakeholders were taken into consideration because the actions and interactions happened with all individuals involved on each project. These actions and interactions help to explain intended and unintended outcomes. For example, given that individuals use voting to decide on dissemination routes, the outcome is a democratic engagement in the project's decisions. A definition of these interaction elements can be found in Table 21 with a representation in Figure 11.

Table 21: Elements of interaction level definitions

Macro Codes for Interaction Level	
How individual actions and interactions combine to produce an outcome.	
Actions	When an individual takes an action to achieve a goal. Example: make a decision on where to publish research results, how often to hold project meetings, and so on.
Interactions	How two or more individuals communicate with or react to each other's actions and opinions. Example: meetings, arguing, disputing, and so on.

Figure 11: Interaction level: from data to mechanism



5.8.3 SYSTEMATIC COMBINING

Identifying the generative mechanisms for knowledge transfer on each project is an iterative process of constant matching of what was found, the broader context, theoretical constructs found in the literature, and the emerging contextualised explanation. Dubois and Gadde (2002) explain this process as systematic combining, a process based on abductive reasoning. The process of systematic combining leads to directing and redirecting the search for more sources of information, and possible explanatory theories to reconstruct the most acceptable causal explanation (Danermark et al., 2002; Dubois & Gadde, 2002). The cornerstone of systematic combining is 'matching' which means "going back and forth between framework, data sources and analysis" (Dubois and Gadde, 2002, pg.556). This process differs from the mainstream positivist literature where the researcher begins from propositions (Yin, 2009), or a 'tight and pre-structured' framework (Miles et al., 2014) or follows specific steps from 'getting started' to 'reaching closure' (Eisenhardt, 1989).

Abductive reasoning was first introduced by Charles Peirce (1931) as a way to bring the search for causality back to social sciences, and stems from the insight that most great advances in science neither followed the pattern of pure deduction nor of pure induction. Lawson (2003) explains how abductive reasoning is often triggered by a surprising or counter-intuitive finding that leads to the question 'Why X and not Y?'. In this study, interview transcripts, documents and observation were used to construct an explanation for knowledge transfer for each of the projects. At this stage, a number of mechanisms were abstracted whilst still avoiding theorising or data reduction. This is where abductive reasoning becomes critical.

Rather than asking the question of what structure or human action caused a phenomenon to happen, the search was for what generative mechanism produced by structure, agency and interactions caused the phenomenon to happen. In practice, immersion in the detail

surrounding each of the projects was necessary. Only when enough detail was gathered and probed, a causal explanation could be conjectured.

The type of mechanisms is classified into different levels: situational, action-formation and transformational, as explained in the analytical framework in the following section. They gradually transpired and are discussed in detail in the Findings chapter. The decision to choose the predominant mechanisms for each project involved abductive reasoning, where the evidence led to the formation of the most plausible explanation. For example, when it became clear that all projects were affected by the impact agenda at the structure level, it was necessary to look for further evidence to why scientists responded to this structural constraint in different ways. It turned out that for SUSSLE it was related to their expertise and scarcity whilst for NIS it was related to maintain a National Capability position. Therefore, the projects were driven by different situational mechanisms.

The next analytical stage is to link the generative mechanisms from the empirical findings to the extant body of theory to find a suitable conceptual framework, which was done through the iterative process of systematic combining (Dubois and Gadde, 2002). A close examination of macro and micro theories allowed for the explanation of the mechanisms. For the situational mechanisms, there was an investigation into macro theories that explain structural constraints and opportunities whilst for the transformational mechanisms there was an investigation into macro theories that explain individuals' interactions such as decision-making type of theories. The action-formation mechanisms were explained by micro theories that ranged from rational to more behavioural types. As it will be discussed in the conclusion chapter, a limitation with this kind of analysis is to find a theoretical framework that is all-encompassing and compatible with the empirical findings. In this study, there were elements of the theories that were used to best explain the generative mechanisms, as discussed in the discussion chapter.

5.9 Analytical Framework

There was a long search for an analytical framework that would successfully help to unfold the generative mechanisms within each knowledge transfer project and consequently form a plausible explanation. Coming from a critical realist paradigm, the interplay among context, structure and agency is a main feature. Because the chosen perspective was to look for mechanisms analytically rather than temporally, the search was taken further afield into different disciplines. To develop a mechanism-based explanation, the basic entities that explain these kinds of phenomena are human agents, their relations, motivations and actions.

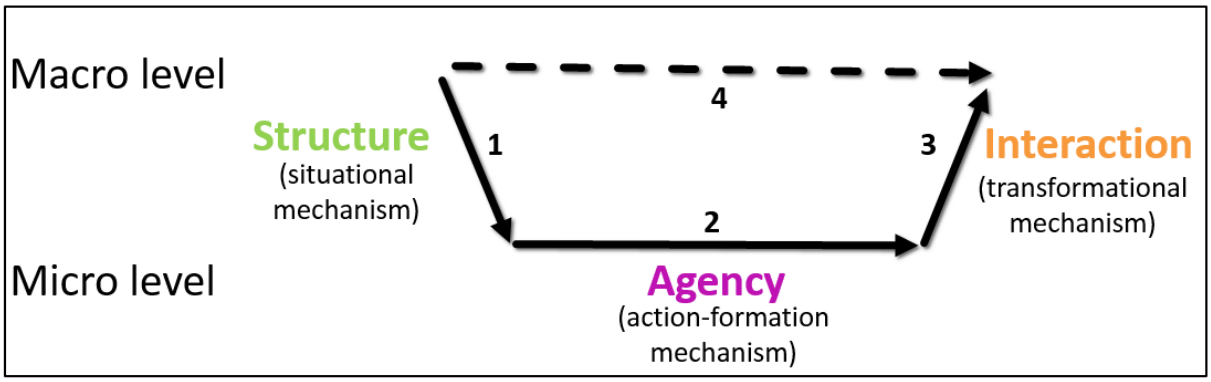
For this reason, Hedstrom and Ylikoski's (2010) framework was applied for identifying and making explicit the mechanisms inherent in a process.

The multilevel nature of the model encouraged a more rigorous thinking about how certain theories might apply to multiple levels of analysis and about the potential boundary conditions of a mechanism approach. This framework is based on the macro-micro-macro model of social action proposed by sociologist James Coleman and is referred to as Coleman's boat (or bathtub) (Coleman, 1994). Coleman's framework has been widely used in sociology to explain social interactions. Transposed to an organisational context/setting, this framework can be substantially informative regarding the micro foundations of the phenomenon under study.

The analytical framework comprises of 3 main levels: structure, agency and interaction, as shown in Figure 12. The structure level will unveil the situational mechanism related to the structural side of the project. Elements of the system (IFR) including norms, rules and resources will help to identify the structural constraints and opportunity for action. The agency level unveils the action-formation mechanism related to agency and the explanation of the actors' behaviours and choices on the basis of his/her motivations and beliefs. The actors consist of research leaders and scientists from IFR and also individuals from the food manufacturers involved on each project. The third analytical level is the interaction, where the transformational mechanism is revealed, relating to the explanation of an outcome which unfolds over time, on the basis of the interaction and actions of different individuals.

This analytical framework promotes going beyond analysing relationships between phenomena exclusively on the macro level (arrow 4). It identifies the "situational mechanisms by which social structures constrain individuals' action and cultural environments shape their desires and beliefs (arrow 1), describes the action-formation mechanisms linking individuals' desires, beliefs, etc., to their actions (arrow 2), and specifies the transformational mechanisms by which individuals, through their actions and interactions, generate various intended and unintended social outcomes (arrow 3)" (Hedstrom and Ylikoski, 2010, pg.58).

Figure 12: Analytical Framework



The situational mechanism is influenced by Erving Goffman‘s (1963) work on public places and Popper‘s (1994) form of situational analysis, where Hedström and Swedberg (1996) use it to build their concept of `situational mechanism´. The assumption is that macro level events affect individuals. The aim is to link social structure or other macro states to the beliefs, desires and opportunities of actors and the emphasis is upon `structure´. Examples of situational mechanisms are material, cultural, institutional, incentives, influence, persuasion, imitation, and power (Elster, 2015).

The action formation mechanism is also known as the individual action mechanism. Through a combination of individual’s motivations, desires, and beliefs, individuals are led to specific actions, and there is an emphasis upon `agency´. Examples of action formation mechanisms are instrumental, strategic, bounded rational, power seeking, utility seeking, value rational, communicatively rational, rule-following, legitimacy seeking, expressive, and impulsive (Elster, 2015).

The transformational mechanism expresses when a number of individuals interact with one another. It describes how these individuals´ actions are transformed into collective outcomes, sometimes unintended and unexpected by all actors. There is an emphasis on agency-agency or interagency. Examples of transformational mechanisms are market, collective action, game, bandwagoning (free riding), balancing, tipping, bargaining (coercive), arguing, positions, rules, socialization, deliberation, and learning (Hedström and Swedberg, 1996).

In the natural sciences, explanations involve a causal agent such as a chemical reaction, whereas in social sciences the agent involves individual actors in order for a process to be analysed. Understanding an explanation is only possible by making the generative mechanism explicit. However, the mechanism itself is usually unobserved, and only observable in its effects. Understanding the individuals’ beliefs and motivations, for example, is extremely useful

in analysing these explanatory mechanisms, even though they can never be observed. They are, therefore, theoretical constructs that provide the links between observable events.

5.10 LIMITATIONS

There are two main types of process-tracing related to the time dimension: temporal and analytical. Analytical studies take a "snapshot" approach by analysing data from a specified period of time, whilst temporal studies involve analysing the data more longitudinally and understanding how the process evolved over a period of time, usually involving many occasions and a recognition of critical junctures. Both approaches are adequate to capture change and understand processes on a detailed level.

This research takes an analytical approach which has the limitation that it does not capture changes over time. Although the projects developed over a period of time and some key participants were interviewed more than once, the analysis was directed at the project as one snapshot and not how it evolved. It might have been interesting to document the development of knowledge transfer cases over time, however, constraints around time, budget and access resulted in an analytical option being chosen for this research. Furthermore, the main interest was in the process of knowledge transfer itself, and thus it was appropriate to choose this analytical design.

Other limitations were the researcher's skills and personal biases, participant's biases, access to the "best" or "right" participants, and access to documentation for triangulation purposes. These limitations were addressed by constant reflexivity from the researcher and being mindful of choosing appropriate projects to the research criteria. A paradigm limitation of using critical realism as the philosophical lens is that it is very time consuming, and is not the conventional philosophical tradition with knowledge transfer scholars. This unconventionality requires detailed explanation, justification and transparency. Critical realism's epistemology involves a lot of interpretation, which is subjective and requires constant reflection.

Although mechanismic explanatory research has a very strong internal validity due to the fine-grained study of cases, it possesses a very weak external validity which makes findings empirically ungeneralisable, although they are analytically generalisable. Another limitation of this research is the narrow study of a single industry context in the UK and the narrow field of knowledge transfer from science to industry. However, this leads to deeper insights into the field of knowledge transfer and a more comprehensive theoretical contribution.

5.11 Conclusion

This chapter explained the research design, procedures for data collection and analysis, and the analytical framework adopted in this research. During the fieldwork, 52 interviews were conducted, totalling 2288 minutes, and 17 documents of 795 pages were reviewed and analysed. In addition to these, 16 events totalling 136 hours were attended. An inductive qualitative methodology of process-tracing was introduced and an outline of mechanisms was proposed. It also described the semi-structured format for interviewing, which is used together with the content analysis of the transcribed text and documentation analysis. Systematic combining through abductive reasoning is the overall analytical method to abstract the mechanisms on each project and match plausible explanatory theories.

This study takes a critical realist approach, using a process-tracing methodology to elucidate the generative mechanisms of knowledge transfer on science-industry projects within the Institute of Food Research (IFR). IFR is considered a leading food research institute in the UK and will become the Quadram Institute Biosciences (QIB) from April 2017. Qualitative analysis on the resulting narratives identifies underlying mechanisms, reveals the micro-foundations for each project and provides insights into why knowledge is transferred. Recently, many researchers have suggested that the study of mechanisms should constitute a central part of studies in the social sciences. Leading scholars such as George and Bennett (2005), Hedström and Swedberg (1996) and Elster (2015) converge on the idea that the study of mechanisms can offer insights that are not usually found in mainstream statistical analyses. Mechanisms are unobservable entities, processes, or structures that generate outcomes and explanations but that do not themselves require explanation.

Whereas correlational analysis involves identifying antecedents regularly conjoined with outcomes, causal analysis consists of specifying the 'mechanism' that underlies and generates empirical regularities and outcomes. These mechanisms explain why a phenomenon happened, and knowledge of their operation allows researchers to go beyond correlations. The widespread use and knowledge of surveys and statistical analyses have improved researchers' ability to describe phenomena and to test theories. The increasing use of these techniques has also fostered the development of a variable-centred type of theorising that only pays scant attention to explanatory mechanisms. Thus, there is an abundance of correlational research, but few mechanismic ones. It is through abstractions and analytical accentuation that generative mechanisms are made visible.

It is also important to understand the different levels at which these mechanism act. This study looks at structural, agency and interaction levels because if we look only at structural conditions and institutional environments, for example, it is difficult to determine how the actors involved in the project behaved and what they were motivated to do. Conversably, looking only at individuals' motivations and beliefs would give an incomplete explanation without taking into account the institutional environment. It is also paramount to understand the interaction of individuals and how they make decisions in order for the phenomenon to happen. The assumption here is that even under strict structural constraints or opportunities, individuals have freedom and motivations to choose how to make decisions and different alternative options. It is also important to understand how individuals come together and aggregate, add or cancel each other out, in this interaction. The next chapter will examine the empirical findings in the light of this integrated framework.

6 FINDINGS AND ANALYSIS

6.1 INTRODUCTION

The aim of this chapter is to uncover the insights gained from the empirical data and to identify the underlying generative mechanisms that are driving knowledge transfer from IFR to industry. One of the objectives of this thesis is to understand why and how this knowledge is transferred. By analysing a selection of projects that took place at IFR and matching the collected evidence to the analytical framework (see Methods chapter). The three selected projects are BACCHUS (a health-driven project), SUSSLE (a safety-driven project), and NIS (a regulation-driven project). Each project will be described and analysed individually. Approaching these three projects from IFR's point of view, this chapter reconstructs insider knowledge and develops a theoretical narrative based on the field data. It draws upon the findings from the data collected, which included documents, semi-structured interviews, literature and webpages (live and archived).

In line with a critical realist stance and its stratified view of reality, one of the aims of this chapter is to present the participants' experiences (the actual stratum), their interactions (the empirical stratum) and the conceptual insights derived from the analysis of these experiences and interactions, to reveal the generative mechanisms underlying knowledge transfer in these projects (the real stratum). The first part of this section offers background information and scope conditions for each project. The second part goes into each of the mechanisms by firstly delving deeply into the data through an inductive approach, in order to gain the necessary background and broader examples of practice. The aim is to reach an analytical level of the mechanism, through the interpretative analysis of these examples.

6.2 HEALTH DRIVEN PROJECT: BACCHUS

6.2.1 PROJECT DESCRIPTION

The "Beneficial effects of dietary bioactive peptides and polyphenols on cardiovascular health in humans" project (BACCHUS) is a large scale, EC funded, collaborative project which ran from October 2012 to September 2016, consisting of 28 partners; 12 of which are leading research organisations with expertise in health claims legislation, and food and health research; and 16 are small and medium enterprises (SMEs). The project is coordinated and led by the Institute of Food Research (IFR). The SMEs involved in the consortium have products or are developing ingredients for products where they need to work with scientists to generate the evidence to support a health claim.

6.2.2 SCOPE CONDITIONS

The main objective of BACCHUS was to understand the cardiovascular benefits from food bioactives. Bioactives are compounds found naturally in many different fruits and vegetables. The aim is to develop tools and resources that will facilitate the generation of robust and exploitable scientific evidence, which can be used to support claims of a cause and effect relationship between the consumption of bioactive peptides and polyphenols, and beneficial physiological effects related to cardiovascular health in humans. This will help small businesses to develop robust scientific evidence to back up health claims for new, innovative food and drink products that will improve cardiovascular health (e.g. by reducing high blood pressure).

BACCHUS is funded by the European Commission Framework 7, where a successful bid was awarded to the consortium led by IFR. The consortium was put together from IFR's contacts and IFR took the lead to write the proposal and then coordinated the project. There are multiple work packages, as shown in Table 22, each addressing a key aspect of the European Food Safety Authority (EFSA) health claim evaluation process (legislation and dossiers; product/bioactive characterisation; habitual intakes; bioavailability; mechanisms and biomarkers; clinical trials evidence on health benefits).

Scientific results and best practice guidelines have been made publicly available and thus can support future health claims by industry. The scope and completeness of the existing bioactive database (eBASIS) that includes both compositional and biological effects data will be extended and developed as a sustainable tool with various training materials.

Table 22: BACCHUS Work Packages

WP1	Best practice guidelines for health claim dossiers
WP2	Development and characterisation of foods and placebos for human and other studies
WP3	Extending eBASIS to study habitual intakes of bioactive compounds in the diet
WP4	Bioavailability and metabolism
WP5	Mechanisms of action
WP6	Physiological effects in humans
WP7	Dissemination, stakeholder engagement and training
WP8	To carry out all project management activities

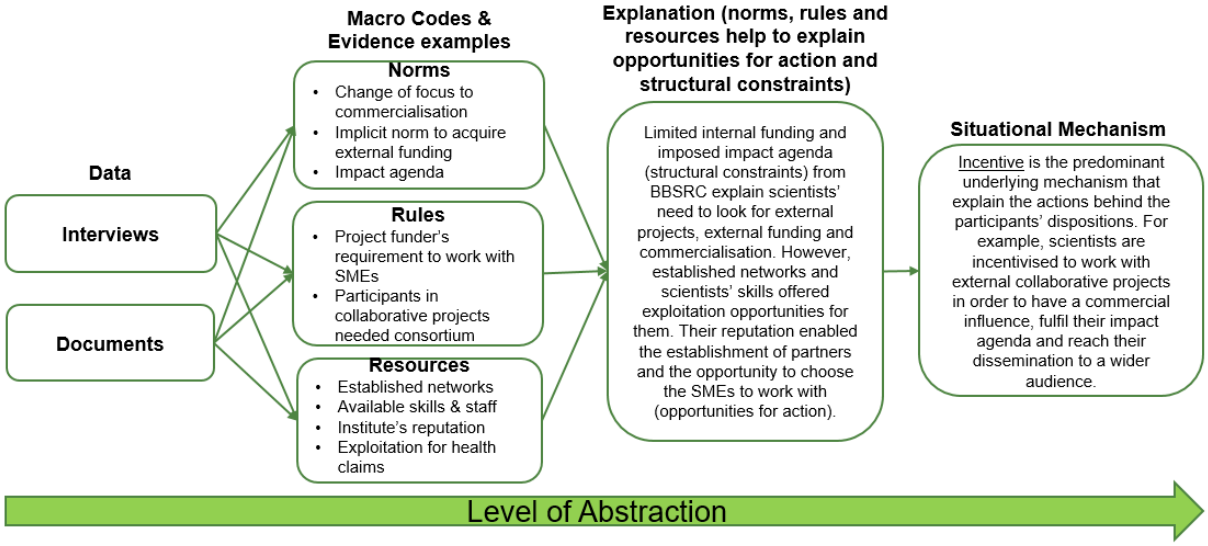
6.2.3 *DISSEMINATION*

All outcomes were disseminated broadly by direct engagement with SMEs via an existing European SME association, with stakeholders via seminars, newsletters and press releases, as well as through traditional scientific routes such as high quality publications and conference presentations. The food SMEs participating in the project directly benefited from its results by utilising them in their product's health claims. A much wider engagement with other SMEs and larger food manufacturers has been achieved through best practice guidelines, publicly available project achievements, training seminars and workshops, press releases and publications in journals such as Nutrients, International Journal of Food Microbiology, and Journal of Functional Foods (BACCHUS, 2016).

6.2.4 *FINDING THE SITUATIONAL MECHANISM IN BACCHUS*

The situational mechanism is related to the structural side of the project, including norms, rules, and resources that will help to elaborate the structural constraints and opportunities, in other words, the macro influence on more micro behaviour. A meaningful explanation is context-bound therefore it is important to be reconstructed from within the project, by playing close attention to local dynamics. The BACCHUS project had a predominant situational mechanism of incentive, as summarised in Figure 13. The following sections will provide a detailed explanation of how the analysis was achieved from the data through the mechanisms. An exemplar with an extended version of Figure 13, which makes explicit the interviews and documents used, is presented in Appendix 4.

Figure 13: Situational Mechanism in BACCHUS



One of the most important indicators of structural opportunities and constraints is related to institutional rules and norms. In the case of IFR, a very significant and recent change has been associated with an increased importance placed on the impact agenda, which requires researchers to ensure that their work makes a difference beyond academia - to policy and practice. All scientists must provide a detailed impact statement to access both internal and external funding.

IFR's core funder, BBSRC, requires an impact statement every four years that details all activities that the institute will be doing to disseminate their research and reach a wider audience. This dissemination can include publications, collaborative projects, industry workshops, press conferences, patents, school's days, spin-outs, and so on. The interview data demonstrates that there is a certain amount of pressure from leadership and the BBSRC, for research leaders to look for external projects and funding, as shown by the evidence examples in Table 23. This point is particularly clear from observations from all interviewees, for example:

> *"Ten years ago the word impact didn't exist whereas now it's all they talk about and every single project has to have an impact statement, a pathway to impact" (I22P23, pg.8).*

However, the core funding provided by BBSRC is not enough to maintain research activities. IFR needs to apply for external funding to be able to do their research. There are many alternative funders, but for IFR the main ones are currently Innovate UK for smaller projects and the European Commission (EC) for larger collaborative projects with industry. The external funding comes with specific conditions, for example, to work closely with SMEs. In the BACCHUS project this condition was made explicit by the EC:

> *"Proposals are expected to have a substantial involvement of SMEs" (EC call KBBE.2012, Guide for Applicants, pg.6).*

Even though participants reported great willingness to participate in the project because it was very relevant and close to their research areas on bioactives, working with SMEs has come across as being a challenge:

> *"Smaller companies are very difficult to work with; they don't know what they want. It's very labour intensive for very little return. Larger companies are much more aware of what they want and knowledgeable about their needs. But you have to follow the requirements" (I22P23 pg.3).*

In order to illustrate the constraint posed by the funding body's requirement, one participant gave a specific example to why external funding is needed:

> *"We get about 170K a year from our core funding (BBSRC) and our external projects are about 800-900K. So a lot more money we get from external but we have to try and map with what we are doing in the core activities" (I7P8, pg.3).*

Another challenge that was overcome by the scientists established networks was that they were able to choose the partners to form the consortium, and so they know most of the direct partners involved in the project:

> *"We have put the consortium together from our own contacts with other academic centres that we knew across Europe. They already have networks of SMEs around them. So we have an absolute framework in the project" (I7P8, pg.1).*

There are a few mechanisms that could be abstracted from this evidence, for example, *institutional, network, persuasion* and *incentive*. It could be argued that the project has been driven partly by an *institutional* mechanism. The strengthening of the impact agenda, together with new norms to disseminate to a wider audience and the need to produce a regular impact statement have been driven by an institutionalised norm which scientists are supposed to adhere to. It could also be argued that the project was driven by a *network* mechanism. It was through IFR's established network that they could put a consortium together from centres across Europe and therefore develop a stronger proposal which was successful.

An alternative but much less prominent mechanism that could be considered in this project is *persuasion*. Persuasion can be defined as "an activity or process in which a communicator attempts to induce a change in the belief, attitude or behaviour of another person ... through the transmission of a message in a context in which the persuadee has some degree of free choice." (Perloff, 1993, pg.14). In other words, persuasion is trying to convince someone through argumentation. Persuasion is closely related to the provision of instrumental incentives, for example, it suggests that a persuader is more likely to be successful when they can provide significant carrots or sticks to the persuadees. In this case, the EC had a weak influence on the research leaders, given that the carrot – funding - is potentially the same as other funders, but the sticks- having to look elsewhere with perhaps less prestige - was of greater influence and could have been more impactful. Whilst an incentive mechanism denotes a more flexible approach to alternatives, persuasion denotes a stronger influence on the

decision to look for alternatives, making incentive a more appropriate situational mechanism for BACCHUS.

The evidence points to a predominant situational mechanism of *incentive*. A mechanism is identified by the kind of effect it produces. In this project, the incentive mechanism captures the process of when scientists are constrained by the lack of internal funding and therefore have to look for external funding that comes with specific requirements. The funding ensures that scientists within IFR can continue with and improve on their research.

An incentive can be defined as "a reward or some form of positive feedback given when a desired behaviour is exhibited " (Dalkir, 2005, pg.309). In economics, an incentive is anything that provides a motive for an individual to perform a particular action, and it is often associated with financial rewards. Other classes of incentives could be placed as moral incentive, where individuals choose the right or admirable thing to do; and also coercive incentives where individuals are led to believe that if they do not act or behave in a particular way, there will be negative outcomes such as punishment or loss of a job. These categories of incentives are not exhaustive but show the range of the meaning of incentive from economic, to social to personal with both positive and negative connotations. Organisations that provide incentives to their members usually have better results than those that provide little or no incentive.

In the case of the BACCHUS project, the incentive mechanism is not explicit as there are no compulsory edicts from IFR saying that scientists should look for external funding and external projects. However, there is an implicit norm that scientists should collaborate with industry and look for external funding to do so. For BACCHUS, this rule was made clear by all participants, who were aware of the need to look for projects and funding opportunities that were close to their research areas and would bring them considerable funding. These informal norms are widely practiced and firmly institutionalised at IFR, as seen by the numerous external projects and the strong impact agenda that has emerged in recent years. As evidence shows, the adherence to this norm can be mostly explained from an incentive based logic rooted in an institutionalised behaviour. Generally speaking, scientists are not always inclined to work with SMEs, however they must entertain scenarios where collaborative work with SMEs is necessary.

One impasse that comes with projects with external funding is that participants must overcome problems of cooperation. This impasse seems to have been overcome by the autonomy of choosing their partners in the consortium. This ability to choose partners can be linked back to IFR's and the scientists' reputations and previous collaborative work that enabled them to

extend their network and form bonds of trust with partners. One could say that these established networks facilitated their disposition to work in this project, which is also linked to an intrinsic incentive mechanism where the scientists are confident working with known partners.

This incentive mechanism is a double-edged sword as the goal of encouraging scientists to do external projects and look for external funding could produce an unintended effect of resentment. The evidence shows that this has not been the case in this project as the scientists willingly put the consortium together, had a successful bid and achieved good results. They have said, however, that SMEs are not necessarily their preferred type of partners. Institutional environments have constraining and enabling effects on behaviour. In this case, they enabled IFR and incentivised scientists, under some unwritten pressure, to participate in this large project. However, different effects can be achieved by altering incentives, altering the impact on actors' position or empowering actors' attributes.

Table 23 offers a summary of some of the evidence collected during fieldwork, providing some quotes from the interviewees. They represent the link between evidence and the structural level macro codes, which are the resources, norms and rules. This evidence helps to support the narrative explanation at the structure level, consequently supporting the abstraction to the situational mechanism.

Table 23: Finding the situational mechanism for knowledge transfer in BACCHUS

FINDING THE SITUATIONAL MECHANISM	
EVIDENCE – QUOTES AND SOURCES OF INFORMATION	**STRUCTURE LEVEL MACRO CODES**
"Proposals are expected to have a substantial involvement of SMEs" (EC call KBBE.2012, Guide for Applicants, pg.6).	Rules (the call required the inclusion of SMEs as part of the project - funding rule)
EC call required consortium agreement (EC call KBBE.2012.2.2-01, pg.13).	Rules (participants in collaborative projects were required to have a consortium agreement, where IFR was the coordinator)
"The rationale to do this project is that it is a research topic that is relevant to what we do at IFR and it brings you the funding. We have to bring in external funding to support what we do" (I30P8, pg.2).	Resources (funding, structural constraint)
"We get about 170K a year from our core funding (BBSRC) and our external projects are about 800-900K. So a lot more money we get from external but we have to try and map with what we are doing in the core activities" (I7P8, pg.3).	Resources (funding, structural constraint)

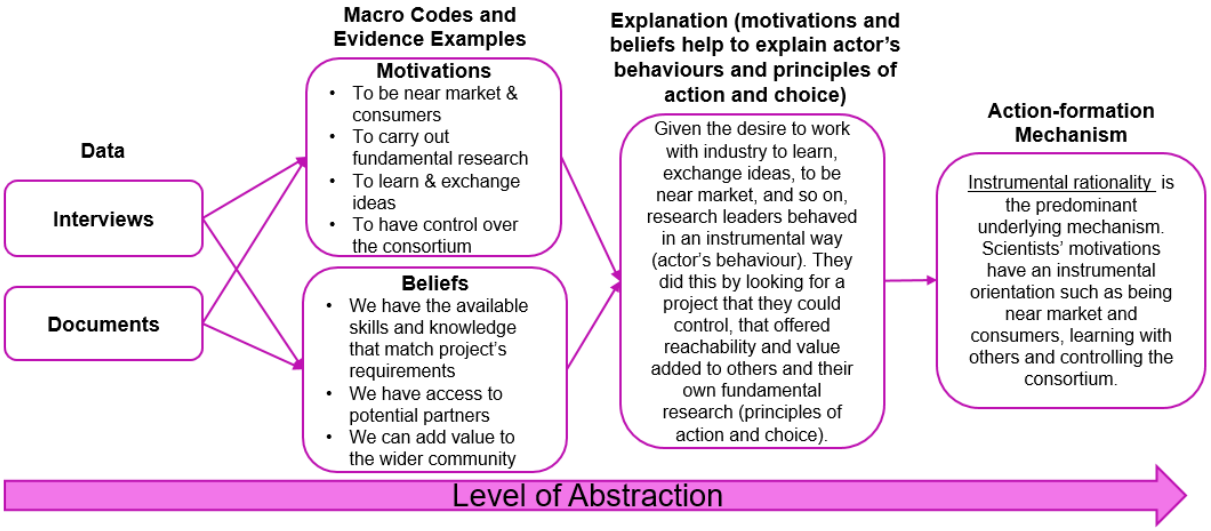
"Certainly the European Commission is very keen to encourage SMEs as most of the European food industry is made of SMEs. I always think that working with SMEs is challenging, but rewarding as well. And you meet some really interesting people" (I7P8, pg.18).	Norms (funding constraint, formation of preferences)
"The project is governed by the description of work, so what we have to do and the deliverables. If there is any intellectual property associated with any publication, they have to be reviewed by the dissemination committee. We also have structures in the consortium agreement to deal with dispute...We haven't had anything up so far" (I30P8, pg.3).	Norm (funding rules, deliverables)
"Ten years ago the word impact didn't exist whereas now it's all they talk about and every single project has to have an impact statement, a pathway to impact" (I22P23, pg.8).	Norms (current expected behaviour)
"I have a chemist, an analytical chemist, people who run human studies, and others who do more routine analysis. In any year, they might only be working with me or they might be working with Richard M., or they are shared. We talk at the beginning of the year and if there are any changes during the year or pressures are too difficult because we've underestimated the commitment it would require, then we just talk through and work it out. It works really well" (I22P23, pg.6).	Resources (available staff and skills)
"We have put the consortium together from our own contacts with other academic centres that we knew across Europe. They already have networks of SMEs around them. So we have an absolute framework in the project" (I7P8, pg.1).	Resources (contacts network)
"Paul F. knew some people and was always travelling around Europe. He kept picking up people (partners) and sometimes it was good, others not so good. Sometimes we had to let some people go" (I22P23, pg.7).	Resources (contacts network)
"We expect to see some exploitation as well. We are hoping that in BACCHUS we will see the take up of what we are doing by more SMEs, so there might be more health claims coming" (I10P10, pg.14).	Resources (exploitation)
"I work with polyphenols, which is one class of bioactives…I knew a number of people I could bring into the project…Paul F. also spoke about a number of people he could bring in. Although there are several hundred publications, there is only one health claim, none for peptides" (I22P23, pg.1).	Resources (contacts network, available skills)
"I think we have a good mechanism for support, both in terms of research we do and other activities like contracts and IPR" (I7P8, pg. 16).	Resources (available support, structural opportunity)
"What the institute is looking for and what big business is always looking for is high quality science and if I was trying to set up a spin out company then I think that would suffer a lot because it's a full time job" (I22P23, pg.13).	Norms (expected behaviour)

"I think one of the challenges in working with small companies is that they do change track very quickly…how to keep them motivated and how to keep them connected to the project can be difficult…also big companies don't go bust as often" (I7P8, pg.7).	Norms (expected to work with SMEs)
"Working with small companies is not straight-forward. So you have to be quite careful who you select. Mostly the SMEs were known to the partners but even then we have lost some of them" (I30P8, pg.8).	Resources (known network)

6.2.5 *Finding the Action-formation Mechanism in BACCHUS*

The action-formation mechanism seeks to explain the actor's behaviour and choice, for example, given the structural conditions they are under, do they act in a rational way, in a value seeking way, by impulse, and so on. Ultimately it looks for an explanation of why people act given their motives and situations, ranging vastly between rational and logical to impulsive and visceral motives. The BACCHUS project had a predominant action-formation mechanism of instrumental rationality, as summarised in Figure 14. The following sections will provide a detailed explanation of how the analysis was achieved from the data through the mechanisms.

Figure 14: Action-formation Mechanism in BACCHUS



One of the gateways into understanding an actor's behaviour and choice is to grasp their motivations. Probing the issue around their motivations to why they formed and worked in this project, questions such as why they wanted to get involved and their objectives for participating were asked. Reflecting on these questions, most participants said that their main reason was to be able to carry out their fundamental research:

> *"I did the project because it allows you to do more research. It funds more research and it's a balance between not being too far off your direction of*

> *travel and retaining focus, which is quite important in a research institute" (I26P23, pg.6).*

Another important element raised by the participants is the tangibility that a project like BACCHUS offered them by creating a direct link between their fundamental research and reaching consumers. This near market experience as well as being closer to a more applied side of their work tends to be only achievable when working in collaborative projects where industrial partners are involved:

> *"We don't put products on the shelves, the food industry does. There's got to be an outcome to the research rather than just me getting some research papers." (I22P23, pg.7)*

> *"Ultimately I can spend 40 years doing polyphenols research in the lab and if it makes no difference to any product in a shelf and a consumer never gets a choice to buy something new, or at least has more certainty that is has a health benefit" (I26P23, pg.6).*

The participants also revealed that their motivation can be more intrinsic and related to enjoyment of learning from others, exchanging ideas and adding value and purpose to their work:

> *"As a researcher I want collaboration. I want to go and learn from them and they learn from me" (I26P23, pg.25).*

> *"I enjoy the exchange of ideas and practice that we are doing" (I7P8, pg.18).*

Another motivation demonstrated in the project can be explained by the actor's favourable control over who they can invite to be in the consortium. This autonomy and power of decision seems to be an important element when taking control of such a large project:

> *"I was keen not to put a whole load of academics with a whole load of strange SMEs. It's really dangerous to do that. It often looks good on paper but often doesn't work…So we all knew each other…it's already a little team, they understand each other" (I22P23, pg.11).*

From these examples and others shown in Table 24, it is possible to argue that research leaders are motivated to collaborate with industry to enable their fundamental research to be carried on, and to be able to reach end consumers. They also believe this kind of project gives added value and reputation to IFR and their own research groups.

There are a few mechanisms that could be considered for this project, for example, *collaboration, self-interest, utility-seeking* and *instrumental rationality*. It could be argued that a *collaboration* mechanism was at play within this project. For example, the scientists were motivated to learn and exchange ideas with others which could have been driven partly by the willingness to cooperate with industry. A *self-interest* mechanism could also be a driver at BACCHUS. Scientists' motivation to be nearer the market and to link fundamental research to consumers could have been driven by a self-interest mechanism. Another less predominant mechanism that could be considered is *utility-seeking*. A utility-seeking mechanism relates to political and economic practices, where individual's actions seek maximisation of their benefits without any thoughts given to interpersonal motivations. This mechanism could be interpreted from the scientists' decisions to organise and lead BACCHUS as this would have a direct financial and reputational gain to their research group.

Nevertheless, from the evidence examined, it is argued that the predominant action-formation mechanism at BACCHUS is *instrumental rationality*. The evidence shows that scientists' motivations for taking part in the project have an instrumental orientation, for example, by being able to do more research, by being nearer the market, and tapping into technologies and products that they do not have. Instrumental rationality is "determined by expectations as to the behaviour of objects in the environment and of other human beings; these expectations are used as conditions or means for the attainment of the actor's own pursued end" (Weber, 1978, pg. 24). In other words, it concerns practical reasoning that helps one decide how to do things, in this case, how to do more research, how to access technologies and achieve more tangible results.

Between the extremes of the visceral-rational continuum, behaviours could be partly motivated by visceral factors, yet somewhat sensitive to cost-benefit considerations such as instrumental rationality, which incorporates interpersonal dispositions that can be both rational and non-economic. Motivations and behaviours may be consequentialist or non-consequentialist, meaning they are either oriented towards the outcome of action or towards the action itself. Instrumental rationality is a consequentialist mechanism as it is oriented towards the outcome of action, and in this case, it is oriented towards the tangible results of health claims. Another consideration is that a long term motivation is distinct from a short term concern. The evidence shows that research leaders have a strong concern for others, mainly for individuals within their research group.

The instrumental rationality mechanism at BACCHUS can also be explained by what Pouliot (2010) called positional agency. Positional agency refers to "those practices that derive from

their performer's location in a field's hierarchical structure" (Pouliot, 2010, pg. 35), meaning that people take action based on the tools and resource endowments available to them. This view helps us to understand why research leaders at IFR were bound to push in the direction of working on the project. Firstly, they have done this kind of project before, which gives them an experience advantage. Secondly, they had a network of potential partners who were easily reachable. Thirdly, it would fulfil their desire to work with products and ingredients affected by their own knowledge.

Table 24 offers a summary of some of the evidence collected during fieldwork, providing some quotes from the interviewees. They represent the link between evidence and the agency level macro codes, which are the motivations and beliefs. This evidence helps to support the narrative explanation at the agency level, consequently supporting the abstraction to the action-formation mechanism.

Table 24: Finding the action-formation mechanism for knowledge transfer in BACCHUS

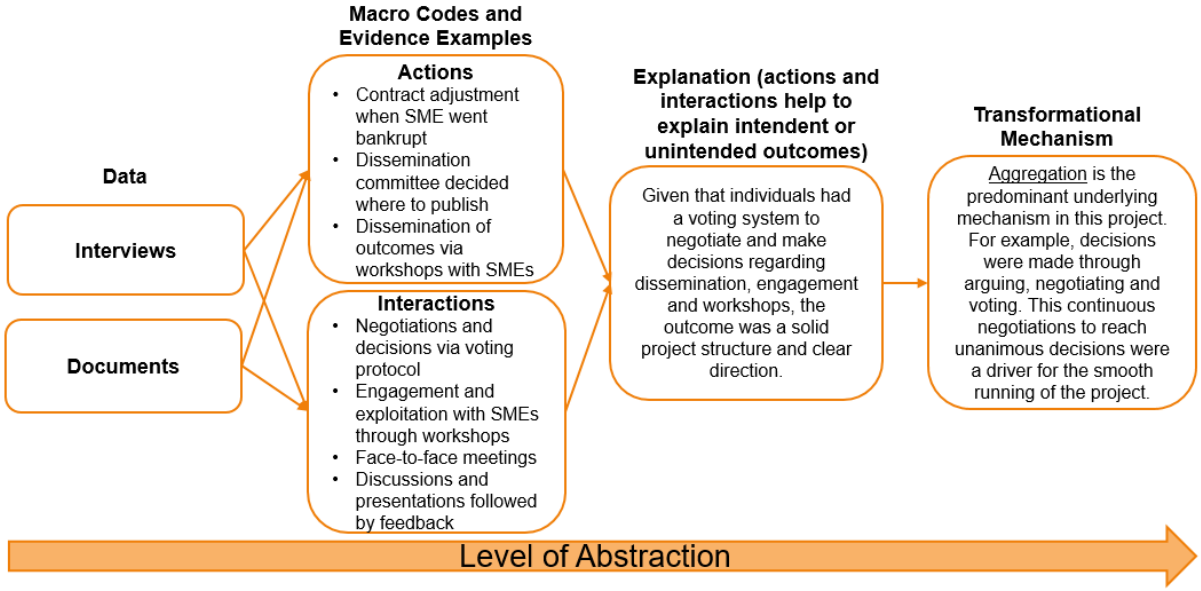
FINDING THE ACTION-FORMATION MECHANISM	
EVIDENCE – QUOTES AND SOURCES OF INFORMATION	**AGENCY LEVEL MACRO CODES**
"There are challenges in working in projects with industry but I enjoy it because of the near market element, it really makes research more tangible" (I22P23, pg.8).	*Motivations (being nearer the market)*
"I know I can do fundamental basic research that fits within that field but to get funding, you need to put together a much bigger broader coherent program. And that's where having contacts with people who have different areas of interest and different focuses" (I26P23, pg.5).	*Beliefs (available skills, access to potential partners)*
"Ultimately I can spend 40 years doing polyphenols research in the lab and if it makes no difference to any product in a shelf and a consumer never gets a choice to buy something new, or at least has more certainty that is has a health benefit" (I26P23, pg.6).	*Motivations (being closer to consumers)*
"I am really interested in working with commercial partners where something tangible might come out of it." (I26P23, pg.24).	*Motivations (tangibility)*
"As a researcher I want collaboration. I want to go and learn from them and they learn from me" (I26P23, pg.25).	*Motivations (learning from others)*
"Although I have a research background, I do have more applied things that I did 10 years ago which is kind of fun because you tend to meet people, it's much more interactive. I enjoy that side of the table so it works quite well" (I7P8, pg.8).	*Motivations (applied research, enjoyment)*
"I did this project because it means I can keep more staff, have a bigger group, and then enhance what we do in the capability, that's sort of win-win really" (I7P8, pg.9).	*Motivations (do more research, keep staff)*

"We provided a lot of intellectual input in terms of which bioactives to look, which foods to get them from, what kind of target levels we would want and why" (I22P23, pg.1).	*Beliefs (having the skills, knowledge)*
"I did the project because it allows you to do more research. It funds more research and it's a balance between not being too far off your direction of travel and retaining focus, which is quite important in a research institute. It allows you to do some elements of research that we can't do ourselves. We don't have processing facilities, we can't make foods, we can't make food grade novel ingredients, industry can. Ultimately if the research we do in food and health is going to make a difference, it's going to underpin in some way the new products on the shelves, supermarkets and shops, or government dietary advice and you have to work with the food industry to do that. We don't put products on the shelves, the food industry do. There's got to be an outcome to the research rather than just me getting some research papers" (I22P23, pg.7).	*Motivations (do more research, tap into technologies, equipment and products)*
"I think the project gives the institute some added value because the sort of people we talk to are more research users or policy people or government" (I7P8, pg.5).	*Beliefs (added value)*
"I was keen not to put a whole load of academics with a whole load of strange SMEs. It's really dangerous to do that. It often looks good on paper but often doesn't work…So we all knew each other…its' already a little team, they understand each other" (I22P23, pg.11).	*Motivations (autonomy and control)*
"I enjoy the exchange of ideas and practice that we are doing" (I7P8, pg.18).	*Motivations (Ideas exchange)*

6.2.6 FINDING THE TRANSFORMATIONAL MECHANISM IN BACCHUS

The transformational mechanism relates to the explanation of an outcome, the interaction and aggregation of individual actions. By describing how individual actions produce various outcomes – intended or not – it is possible to form a narrative that is related to how project partners made different decisions that produced outcomes such as dissemination and engagement. Therefore, there is an interdependence among the actions, interactions and outcome. The BACCHUS project had a predominant transformational mechanism of aggregation, as summarised in Figure 15. The following sections will provide a detailed explanation on how the analysis was achieved from the data through the mechanisms.

Figure 15: Transformational Mechanism in BACCHUS



Many outcomes occur through some form of decision making such as voting and bargaining. Questions were asked such as how partners come together to make decisions – from publications to human studies, what were the intended outcomes from taking part in such a project, and how dissemination took place, as shown as an extended version of the evidence in Table 25. Pondering on such fundamental questions, the participants started to reflect on how their interactions with other stakeholders affected the outcomes of the project.

Being an EC funded project, formal processes regarding responsibilities, dealing with disputes, governance structure, financial provisions, dissemination, engagement and so on, are pre-set in the consortium agreement even before the project starts. For example, decisions can only be taken if two thirds of the partners agree and members also have veto rights:

> *"Decisions shall be taken by a majority of 2/3 of the votes" (Grant Agreement No312090, pg.11).*

> *"A member which can show that its own work, time for performance, costs, liabilities, intellectual property rights or other legitimate interests would be severely affected by a decision of a Consortium Body may exercise a veto with respect to the corresponding decision or relevant part of the decision" (Grant Agreement No312090, pg.12).*

Although the participants were somehow restricted on how to interact and make decisions due to the funder's requirements, these restrictions were seen as positive as they gave a solid structure on how to proceed:

> *"BACCHUS work project is pretty well defined. So we have a plan in place, there will be some exploitation and engagement that we set out to do and we get measured on several different ways in terms of deliverables, reports and papers" (I7P8, pg. 13).*

As a large project with several partners, tracking and coordinating all of the objectives was not an easy task. Partners have also used meetings and interactions to understand each other's responsibilities, and to give and receive feedback:

> *"By telling everybody what you've done, people can give feedback, question things, suggest ways to do it better. If you think, actually if you change that, question why you are doing it differently, even if it doesn't say in the contract…we can go back and change the contract" (I26P23, pg.12).*

When asked about tools used to disseminate their results and share with the wider food industry, the participants related to a range of dissemination approaches, one of them being regular workshops with industry where their findings are shared with SMEs that are not direct partners:

> *"We hold SME specific workshops where SMEs come along. We try to go outside the project consortium and talk to SMEs that are doing health claims" (I7P8, pg. 18).*

The several dissemination routes also allowed participants to engage in activities such as publishing in academic journals, conferences and workshops. So far the results from the project have been published in prestigious journals such as International Journal of Food Microbiology (2015), International Journal of Molecular Science (2015), Evidence-Based Complementary and Alternative Science (2013), Nutrients (2015), Journal of Chromatography (2015), Agriculture Food Chemistry (2015, 2014 and 2013), Functional Foods (2015), Recent Advances in Polyphenol Research (2013); magazines such as Food Manufacturer government websites, press releases, conference proceedings and so on. These results boosted the positive reputation and perceived strength of IFR in this field.

A similar picture emerged when asked about tools used to make decisions. For example, human studies are a key element of the project as it will provide the main evidence for health claims. When deciding on specific details of how to achieve this, many crucial elements had to be negotiated, voted, and ultimately decided:

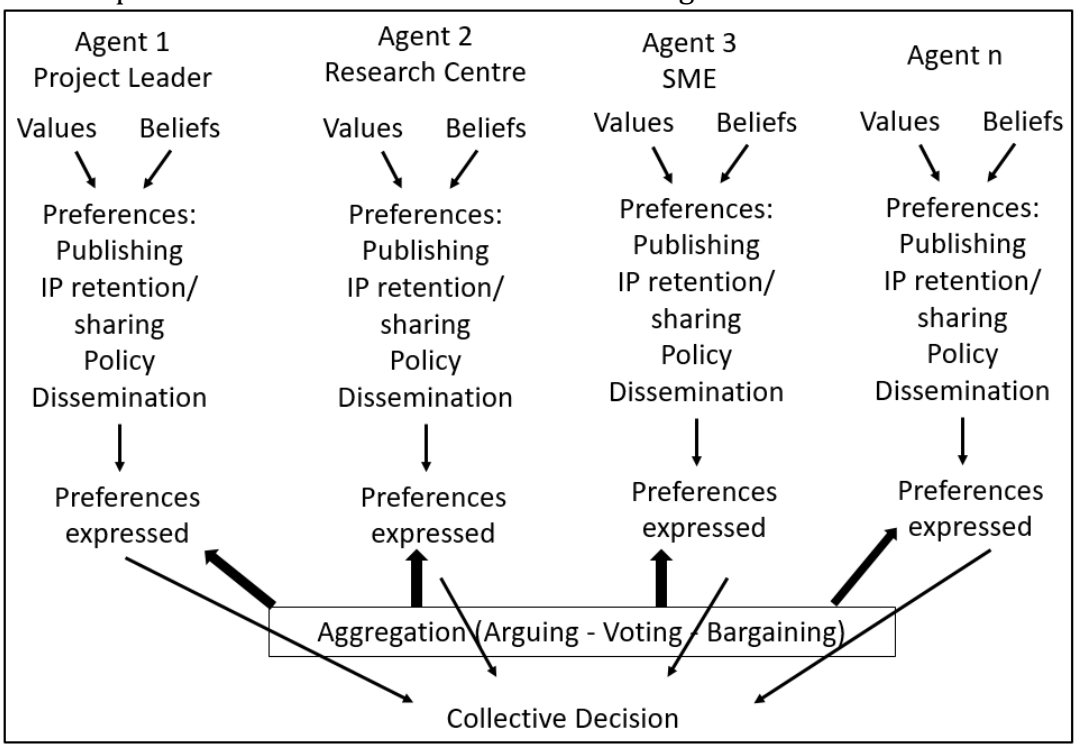
> *"When we had to decide the details on human studies, we did a 2-day event where we thrashed out all details and critiqued everything. All we were*

> *actually doing was looking for properly conducted trials and best practice publishing trials, which a lot of people don't do it. It's just scientific excellence, that's how I see it" (I26P23, pg.15).*

There are some mechanisms that could be abstracted from this evidence, for example, *learning, negotiation* and *aggregation*. The mechanism of *learning* could be explained in two ways. Firstly, it was present within the meetings and discussions, where partners gave and received feedback on their presentations. These interactions offered opportunities for questioning and learning from each other. Secondly, a learning mechanism was present during the engagement workshops with SMEs, where tools and results were presented. *Negotiation* could also be considered as a less predominant mechanism that was present during events, discussions and decisions such as next-steps and dissemination routes.

Although voting is the formal procedure for decision-making at BACCHUS, it is argued that the main transformational mechanism expressed is *aggregation*, as summarised in Figure 16. The aggregation mechanism denotes "any process in which actors who may have initially different preferences interact to bring about a decision that all of them accept as binding" (Elster, 2015, pg. 400). An aggregation mechanism in decision making could be conveyed by arguing, bargaining and voting. Many examples given by the participants involved some level of arguing and also voting, for example, when decisions had to be made on human studies and also when to recruit for a new SME because the previous one had gone bankrupt. Bargaining occurs "in situations of mixed cooperation and conflict" and implies "the use of tactics and strategies to obtain an agreement favourable to themselves" (Elster, 2015, pg. 414). Although IFR, as the project coordinator together with the dissemination committee, potentially have higher bargaining power over other partners, bargaining tactics occurred seldom. It could be argued that one example of bargaining occurred when choosing dissemination routes, for example, the choice of journals to publish.

Figure 16: Representation of collective decision-making in BACCHUS



The possibility of persuading others with a convincing argument and the norms of mutual agreement work as a great equalizer for BACCHUS negotiations. Joining the project involves more than behavioural adaption to the funding's pre-established norms but also continuous negotiations to reach unanimous decisions. This adaptation within BACCHUS includes specific approaches in the collective decision-making process itself. For example, arguing "is the effort to persuade by reason giving" (Elster, 2015, pg. 403) which implies debates and negotiations usually motivated by collective interest.

Table 25 offers a summary of some of the evidence collected during fieldwork, providing some quotes from the interviewees. They represent the link between evidence and the interaction level macro codes, which are the actions and interactions. This evidence helps to support the narrative explanation at the interaction level, consequently supporting the abstraction to the transformational mechanism.

Table 25: Finding the transformational mechanism for knowledge transfer in BACCHUS

FINDING THE TRANSFORMATIONAL MECHANISM	
EVIDENCE – QUOTES AND SOURCES OF INFORMATION	**INTERACTION LEVEL MACRO CODES**
"Within the project we have meetings every 9 months, face-to-face. All the partners turn up and present what we've been doing" (I26P23, pg.12).	Interactions (face-to-face meetings) Interactions

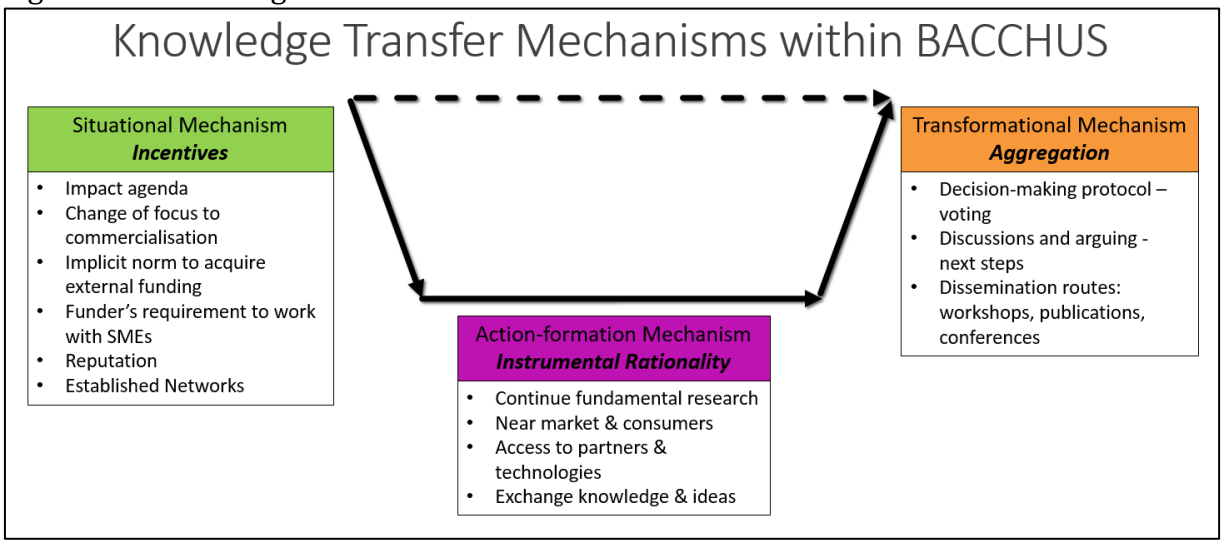
"By telling everybody what you've done, people can give feedback, question things, suggest ways to do it better. If you think, actually if you change that, question why you are doing it differently, even if it doesn't say in the contract…we can go back and change the contract" (I26P23, pg.12).	(feedback and discussion)
"We had to change the contract a couple of times mainly because partners went bust. But also in two cases the science, our scientific position changed and it made no sense to do what was written in the contract" (I26P23, pg.13).	Actions (adjusting contract)
"There are formal processes in the grant agreement on how decisions are made but if there is no general agreement, then we also vote" (I26P23, pg.13).	Interactions (formal agreement, voting)
"The decision of where to publish is made by the lead partner on that paper and then we send it out to the dissemination committee. If there is any issue, say IP that a company doesn't want to publish because it reveals too much about the process then we negotiate a deal. That's why it goes through the dissemination committee" (I26P23, pg.15).	Actions (negotiations, decisions, dissemination)
"When we had to decide the details on human studies, we did a 2 day event where we thrashed out all details and critiqued everything. All we were actually doing was looking for properly conducted trials and best practice publishing trials, which a lot of people don't do it. It's just scientific excellence, that's how I see it" (I26P23, pg.15).	Actions (decisions making through workshops, critique, negotiation)
"BACCHUS work project is pretty well defined. So we have a plan in place, there will be some exploitation and engagement that we set out to do and we get measured on several different ways in terms of deliverables, reports and papers" (I7P8, pg. 13).	Actions (exploitation, dissemination and engagement)
"We hold SME specific workshops where SMEs come along. We try to go outside the project consortium and talk to SMEs that are doing health claims" (I7P8, pg. 18).	Interactions (dissemination of outcomes)
"We have meetings face to face and quite a lot of Skype online meetings. It is quite a heavy program of managing it and interacting with the SMEs in the project but we also have an external activity dealing with it, while connecting with SMEs. We have a whole work package that deals with dissemination" I30P8, pg. 2).	Interactions (decisions, negotiations, dissemination)
"We have a dissemination committee that is made up with some of the partners…they review any publications before they are submitted. There are also structures in the consortium agreement to deal with disputes or problems. We haven't had anything up to now" (I30P8, pg. 3).	Interactions (publications, disputes)
"We had 3 workshops so far for the wider SMEs to come and listen…we have a dissemination plan sent to 3000 companies and we hope to get 50 to 60 on each workshop, that's the aim" (I30P8, pg. 5).	Interactions (dissemination of outcomes)
"When we meet face-to-face, everybody makes a short presentation of the work they've done. So that's when you're actually all in the room together that you suddenly get this light bulb moment where you think "Oh, that's how mine fits with yours" that's why we have to have these	Interactions (decisions, sharing ideas and moving forward)

meetings otherwise you wouldn't talk to each other because there are so many people" (I29P28, pg. 2).	
"There are different work packages and each one of the people who is in charge of each package will be the person you go first for decisions. But actually most decisions were made prior to the project starting because its EC funding want to know exactly before you started what you are going to produce. So most decisions have been made and there are tweaks that get done time to time" (I29P28, pg. 3).	Interactions (decisions, negotiations)

6.2.7 *SUMMARY*

There are three predominant mechanisms affecting knowledge transfer at BACCHUS: *incentives, instrumental rationality and aggregation,* as summarised in Figure 17. The shift of IFR's focus from mainly publications to also include commercialisation required scientists to face the challenge of looking for external projects and funding. Driven by an *incentive* mechanism, this challenge promoted an unwritten norm of seeking funding for projects which, in this case, came with the pre-requirement to work with industrial partners, more specifically, food manufacturer SMEs. Due to IFR scientists' reputation and established networks, their ability to choose the other partners for the project had a positive implication. IFR scientists involved in the project also had a desire to continue their fundamental research, being nearer market and accessing partners and technologies that they would otherwise not be able to if they did not participate in BACCHUS. From this *instrumental rationality* mechanism, the scientists chose to take part within this project among other potential options of funding and partners. Finally, through an *aggregation* mechanism, key decisions regarding where to publish, dissemination routes, which partner to bring in, and so on, were made by voting, discussions and argumentation.

Figure 17: Knowledge transfer mechanisms in BACCHUS



6.3 SAFETY DRIVEN PROJECT: SUSSLE

The **Sus**tainable **S**helf **L**ife **E**xtension, or SUSSLE project, ran from August 2008 to March 2012, and it was funded by the LINK Programme (now Innovate UK) in association with the Chilled Food Association (CFA), Defra, IFR, BBSRC and Unilever, costing £750K. The project was coordinated by research leaders from IFR and CFA's director. CFA represents many of the UK's biggest chilled food manufacturers, and their members supply major retailers with chilled foods ranging from sandwiches to prepared salads, prepared meals and desserts. CFA also provides its members with best practice guidance, training tools and access to fundamental research findings regarding sustainable practices, food safety, hygiene, and so on.

Chilled food production in the UK is one of the world's fastest-growing, most innovative and advanced food sectors. Currently worth around £12bn, it employs more than 60,000 people and each year puts over 12,000 different chilled foods on shelves (CFA, 2016). The food industry claims to use high quality raw materials and good hygienic manufacturing practice along with a strict set of safety criteria when producing foods. The safety criteria include precisely defined cooking conditions and times, as well as controlled storage temperatures and use by dates that keep food safe. The rare outbreaks of foodborne botulism have occurred when these criteria have not been followed correctly. Although these criteria are well established, consumer demand for reduced preservatives, milder heat processing and longer shelf lives is driving continuous innovation in minimally processed chilled foods, which include ready meals and similar prepared items. But delivering this needs a full understanding of how these changes affect the germination and growth of food poisoning bacteria, especially *C. botulinum*.

The aim of the SUSSLE project was to understand the levels of a bacterium *Clostridium botulinum* in raw food ingredients to help the food industry deliver safe chilled foods more sustainably. Botulism is a form of food poisoning, caused by a deadly neurotoxin produced by this bacterium. The neurotoxin is so poisonous that even the tiniest amount of food in which *C. botulinum* has germinated, grown and formed neurotoxin can result in severe illness and death. The project involved doing a risk assessment that combined both microbiology data and mathematical modelling, which are IFR's research leaders' expertise.

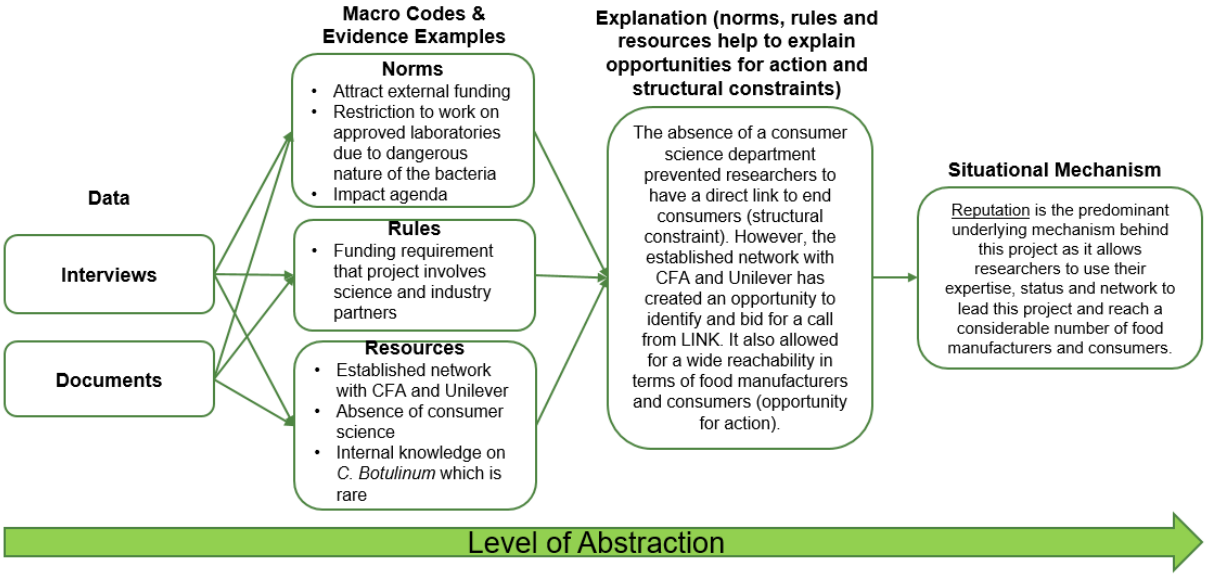
The SUSSLE project allowed reduced cooking time and temperature, improving taste and reducing energy use. It also allowed for extension of shelf life and consequently the reduction of food waste. Through the SUSSLE project, products are now on supermarket shelves that

have been produced with lower energy inputs, with safe extended shelf lives, and improved consumer acceptability. Many members of the Chilled Food Association have benefitted from the project to date, through attending workshops hosted by IFR. After 1st January 2018 manufacturers who are not members of the CFA will also be able to access the SUSSLE technology on special terms.

6.3.1 SITUATIONAL MECHANISM IN SUSSLE

The situational mechanism is related to the structural side of the project, including norms, rules, and resources that will help to elaborate the structural constraints and opportunities, in other words, the macro influence on more micro behaviour. A meaningful explanation is context-bound therefore it is important that it is reconstructed from within the project, by paying close attention to local dynamics. The SUSSLE project had a predominant situational mechanism of reputation, as summarised in Figure 18. The following sections will provide a detailed explanation of how the analysis was achieved from the data through the mechanisms.

Figure 18: Situational Mechanism in SUSSLE



Institutional norms such as the current emphasis on applied research and the need to work with industry and look for external funding, offers a chance for research leaders to seek these opportunities, as shown with an extended version of evidence in Table 26. These norms can be illustrated as follows:

> *"There is an expectation that we are bringing a certain amount of external funding" (I28P13, pg.16).*

> *"I've got a long run of the things here. We've been through several cycles where the BBSRC emphasis is publishing in Nature and don't do any of the applied stuff. Then we'll go to a situation where you've to actually contact the community. It literally goes in cycles and each one is designed to last 7 years. We're on the upward side of the applied curve" (I25P26, pg.2).*

An important example of a resource that created an opportunity for action is the network already established by IFR research leaders that led to the identification of a call from LINK. The LINK programme was a government initiative to fund fundamental research that is collaborative with industry. Later the LINK programme was taken over by the Technology Strategy Board (TSB) which then became Innovate UK. When a call on improving food manufacturing came up, research leaders at IFR quickly recognised they not only had internal research capability to address food manufacturing issues, but also had a network of contacts that would enable them to quickly put a proposal together:

> *"A call from LINK (Innovate UK) came along to improve food manufacturing and then you try to think if you could do something, which partner you would need. I remember I was in Cambridge with Karen (CFA's director), Mike and someone from Unilever, and we decided to go forward with something about shelf-life. It literately was a network that already existed in terms of contacts and things like that. The call stimulated a discussion which stimulated a proposal" (I33P26, pg.1).*

Another key resource opportunity identified by the research leaders at IFR was the fact that previously they have worked with the Chilled Food Association (CFA). This association has the largest number of chilled foods manufacturers in the UK as members. This established network between IFR and CFA meant that they had wider access to a greater number of companies instead of directly working with individual companies:

> *"All the major chilled food producers in the UK are part of CFA so there is a big reach. They estimate the value of the work for this project to be 25 million (British) pounds a year" (I28P13, pg.10).*

An additional benefit from these established networks, particularly with Unilever, meant that IFR could easily have a consortium that would fulfil the funding's criteria:

> *"Unilever is one of the few large food manufacturers who do get involved in research. LINK (Innovate UK) likes to fund projects to be industry-led and who can put money in the project and there aren't many companies that can do that. Unilever is one of them. We have a relationship with Unilever that*

> *goes back 30 years…a project that went forward to LINK would need that kind of shared support so it fitted well…" (I33P26, pg.1)*

The reputation from the research leaders and the scarcity of alternative research centres that have the knowledge about this particularly dangerous bacteria – *Clostridium botulinum* - also meant research leaders at IFR had an advantage in bidding for the LINK funding:

> *"Clostridium botulinum is so difficult and dangerous to work with and only very few places in the world can do this sort of work and we are one of them. Industry wants to extend the shelf-life of their products and decrease the heat treatment, without adding preservatives. To do that they have to come to a lab with a series of expertise. Globally we are one of the few labs to do that…we are well known, we publish a lot and speak at a lot of conferences" (I12P13, pg.1).*

There was a lack of resources that created institutional constraints that would enable IFR's scientists to reach consumers, one of them being the absence of a consumer science department within the institute. This prevented research leaders from having a direct link to the end consumers. Projects like SUSSLE are opportunities for research leaders to work together with the food industry, in this case with Unilever and CFA members (food manufacturers), thus seeing their science reach the wider population. Even though this reach is indirect and their innovation is not visible to consumers, the process behind the products is influenced by the science brought from IFR research:

> *"This kind of hidden innovation, what we are doing is innovating, helping the companies to innovate in processing…food safety where the consumer sees the same product but it is produced in a very different way. And that's a nice bit of innovation because the industry said there is a need…how can we use science to address that need" (I6P7, pg.14).*

A few mechanisms can be abstracted from the data. For example, *network*, *institutional, scarcity,* and *reputation*. The *network* mechanism could be explained as the mechanisms that gave rise to the opportunity that made the scientists aware of such a project. It was through IFR's established networking partners that they found out about the funding and the project's requirements. It could also be argued that an *institutional* mechanism was in place in relation to the changing norms and institutional environment which now requires scientists to work closely with industry. Another mechanism that could be asserted is *scarcity.* Because IFR has scarce expertise and lab facilities to work with *C. Botulinum*, it had an advantage in bidding for the project. Nevertheless, from these examples, it is argued that a predominant situational mechanism within the SUSSLE project is *reputation.*

Taking into consideration the contextual situation in this project, research leaders have a reputation that influences the way they adopt strategies so that their science reaches consumers. This is an important mechanism that determines the resources that research leaders draw upon for achieving their goal. For example, their rare expertise in the dangerous bacteria, their international status from working in this area, their previous involvement with CFA, and their relationship with Unilever.

Reputation is the opinion that people in general have about someone or something, or how much respect or admiration someone or something receives, based on past behaviour or character (Klein, 1997). In this case, reputation is valued on instrumental grounds, not on intrinsic ones, and forms a base of trust and cooperation. If a priori trust relationship exists, collaboration in a new project is executed more easily, as reputation can be a good measure of someone's contribution to the project.

A structural constraint within IFR is the lack of direct facilities to transfer their fundamental science downstream to consumers. One way of achieving this translation is through project opportunities like LINK. The wider reach achieved by working with organisations such as CFA translates into a much more rewarding experience than working with individual organisations. Furthermore, having established links with very large companies such as Unilever makes the bidding for this kind of funding more achievable.

One of the biggest advantages of IFR research leaders is that they have an expertise in this bacteria that is rare and sought after. This expertise has been developed over many years of research and an international reputation. This influence was a key factor in the successful bid. This reputation mechanism made it possible for research leaders at IFR to work more closely with industry and to have their fundamental science and findings used in a meaningful way that will produce safer food manufacturing processes and less food waste.

Table 26 offers a summary of some of the evidence collected during fieldwork, providing some quotes from the interviewees. They represent the link between evidence and the structural level macro codes, which are the resources, norms and rules. This evidence helps to support the narrative explanation at the structure level, consequently supporting the abstraction to the situational mechanism.

Table 26: Finding the situational mechanisms for knowledge transfer in SUSSLE

FINDING THE SITUATIONAL MECHANISM	
EVIDENCE – QUOTES AND SOURCES OF INFORMATION	**STRUCTURE LEVEL MACRO CODES**

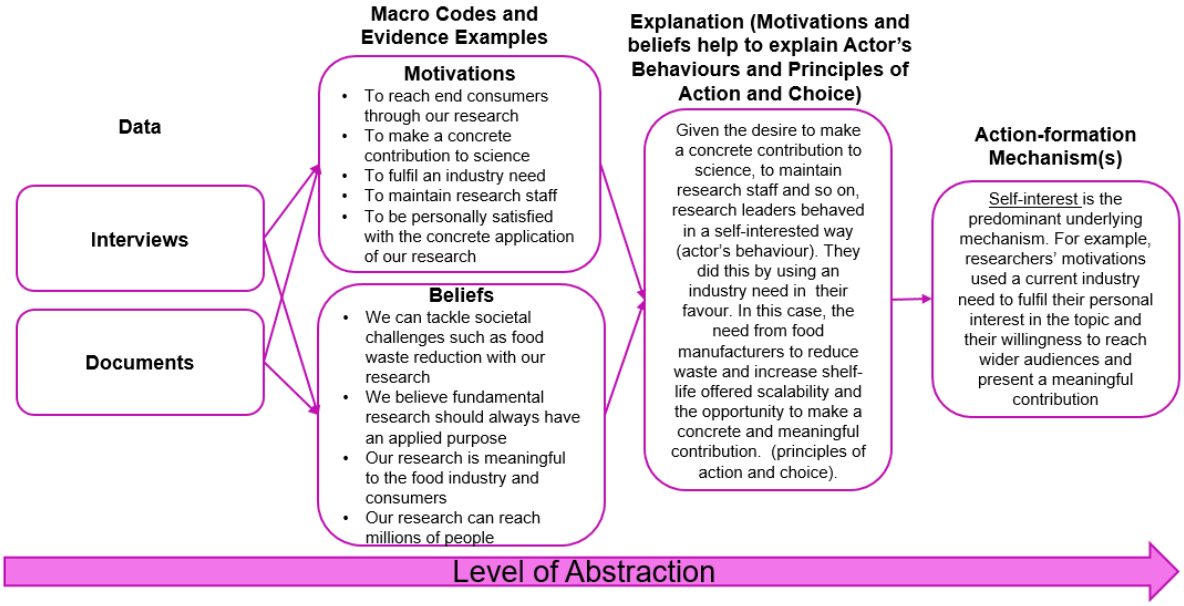
"Originally I got the project but what we achieved was entirely due to both of us equally…The project worked because my colleague did the maths and I did the microbiology, and we were able to discuss together how, what data we needed and what analysis was needed" (I28P13, pg.3,4).	Resources (available capabilities and skills)
"I have previously worked with CFA and would be easier to reach more companies through them rather than working with companies individual" (I28P13, pg.4).	Resources (established network, wider reach)
"All the major chilled food producers in the UK are part of CFA so there is a big reach. They estimate the value of the work for this project to be 25 million pounds a year" (I28P13, pg.10).	Resources (reachability, value added)
"There is an expectation that we are bringing a certain amount of external funding" (I28P13, pg.16).	Norms (attract external funding)
"Clostridium botulinum is so difficult and dangerous to work with and only very few places in the world can do this sort of work and we are one of them. Industry wants to extend the shelf-life of their products and decrease the heat treatment, without adding preservatives. To do that they have to come to a lab with a series of expertise. Globally we are one of the few labs to do that…we are well known, we publish a lot and speak at a lot of conferences" (I12P13, pg.1).	Resources (scarcity, reputation, expertise)
"We always do the tests here because from a safety perspective we are not allowed to move it. And also there are government restrictions on potential terrorism agents. Clostridium botulinum is on that list as well, so we are not allowed to move it from the lab" (I12P13, pg.4).	Norms (restriction to specific laboratory work)
"I've got a long run of the things here. We've been through several cycles where the BBSRC emphasis is publishing in Nature and don't do any of the applied stuff. Then we'll go a situation where you've to actually contact the community. It literally goes in cycles and each one is designed to last 7 years. We're on the upward side of the applied curve" (I25P26, pg.2).	Norms (current impact environment)
"There was an incident in New Zealand about 2 years ago, where this company had to withdraw a lot of their products, white formula products, because of the potential small contamination. So, we're talking about a billion dollar incident. Most of the other companies want to protect themselves from incidents like that…and we can do these kind of risk assessments" (I25P26, pg.4).	Resources (available skills)
"If you are going to do collaborative work with industry it has to be pre-competitive. So, the larger food companies are happy to be pre-competitive but none of the smaller ones can afford to be pre-competitive. It's not something they can do. In that case, working with an organisation like CFA, who's an umbrella organisation that looks after a sector, then the sector tries to move forward in a positive way" (I25P26, pg.5).	Resources (established network, working with CFA, pre-competitive area)
"I've seen 10 meters wide lasagne made on a conveyer belt, it gets manufactured, cooked and layered with béchamel all the way along. Most people don't appreciate that's what they are buying from a supermarket. It's very different keeping that safe and finding the right	Resources (available knowledge to help an industry need)

functionality for the factory so they can keep it safe than it is doing it at home" (I25P26, pg.8).	
"We don't really have a consumer's science; we don't have it all. Consumer science are a massive part of the business, and all of the companies know what their consumer wants, and they're testing that all the time" (I25P26, pg.9).	Resources (lack of consumer science, no direct link to consumers)
"A call from LINK (Innovate UK) came along to improve food manufacturing and then you try to think if you could do something, which partner you would need. I remember I was in Cambridge with Karen (CFA's director), Mike and someone from Unilever, and we decided to go forward with something about shelf-life. It literately was a network that already existed in terms of contacts and things like that. The call stimulated a discussion which stimulated a proposal" (I33P26, pg.1).	Resources (established network, expertise, funding available)
"Unilever is one of the few large food manufacturers who do get involved in research. LINK (Innovate UK) likes to fund projects to be industry led and who can put money in the project and there aren't many companies that can do that. Unilever is one of them. We have a relationship with Unilever that goes back 30 years…a project that went forward to Link would need that kind of shared support so it fitted well…" (I33P26, pg.1)	Rules (funding rules)
"We've both done work on safety of chilled foods. We keep speaking to companies at the moment I'm speaking to maybe 10 around solving some problems that they have with regards to their chilled food, because they are always looking to increase the shelf life or lower the heat treatment or reduce the waste. This particular project was driven by waste reduction because with food with such short shelf lives the food waste is massive" (I28P13, pg.4).	Resources (fulfilling industry needs)
"This kind of hidden innovation, what we are doing is innovating, helping the companies to innovate in processing…food safety where the consumer sees the same product but it is produced in a very different way. And that's a nice bit of innovation because the industry said there is a need…how can we use science to address that need" (I6P7, pg.14)	Resources (available skills, fulfilling an industry need)

6.3.2 ACTION-FORMATION MECHANISM IN SUSSLE

The action-formation mechanism seeks to explain the actor's behaviour and choice, for example, given the structural conditions they are under, do they act in a rational way, in a value seeking way, by impulse, and so on. Ultimately it looks for an explanation on why people act given their motives and situations, ranging vastly between rational and logic to impulsive and visceral motives. The SUSSLE project had a predominant action-formation mechanism of self-interest, as summarised in Figure 19. The following sections will provide a detailed explanation of how the analysis was achieved from the data through the mechanism.

Figure 19: Action-formation Mechanism in SUSSLE



Research leaders' motivations to participate in a project like SUSSLE seem to be directly linked to their personal concern with societal challenges such as reduction of waste, energy usage, and greenhouse gases, as shown with an extended version of the evidence in Table 27:

> *"When you can safely extend the shelf life it has a massive effect not just on the profits of the company, but the reduction of waste, environmental concerns about reduced processing and so on. And all of those things are massive and possibly underrated…about a third of all the food manufactured is actually wasted but only a small part is from the consumer. A lot of it is from the manufacturing domain because of the way they have to satisfy certain regulations in terms of intermediate storage and so on. Understanding that leads to massive reductions in waste and energy usage and reduction in greenhouse gases and all things like that most people don't see" (I33P26, pg.3).*

Other drivers for their motivations are the wider reach to end consumers as well as the importance of knowledge exchange and learning from industry that you gain whilst working with industrial partners. This knowledge exchange appears to be fundamental in educating their decisions on the direction of their research.

> *"The reason why I did this project, well, it's complicated. I think we should, all the research leaders here should run an applied fundamental program of research. That is what I'm trying to do, fundamental research. We do high quality molecular biology, very good stuff we do. And we do applied work,*

> *which is mainly with the food industry. We get to learn a lot about what they do, which helps us to do our job much better" (I12P13, pg.6).*

The importance of the link between fundamental research and applied science and making a concrete contribution to science is a key motivator to research leaders.

> *"I'm a mathematician and I've been at IFR for 33 years and now work in areas of food safety risk assessment. In all that time I've always maintained industrial contacts in industry research. So I've worked with many, many companies. Some of the biggest food companies in the world, some small ones as well and continue to do so. I don't think I would ever consider researching without doing this really. I've tried to maintain a balance 50-50 between sort of what I would call applied translational research and what I would call more pure academic type research" (I25P26, pg.1).*

Coming from the principle that there is an industry need in terms of increasing shelf-life and reducing food waste, the research leaders used this need in their favour to leverage their bid for the project proposal:

> *"We've both done work on safety of chilled foods. We keep speaking to companies. At the moment I'm speaking to maybe 10 around solving some problems that they have with regards to their chilled food, because they are always looking to increase the shelf life or lower the heat treatment or reduce the waste. This particular project was driven by waste reduction because with food with such short shelf lives the food waste is massive" (I28P13, pg.4).*

There are some mechanisms that could be derived from this evidence, for example, *cooperation, rewards, altruism* and *self-interest*. It could be argued that IFR scientists were motivated by a *cooperation* mechanism. Because there was a clear industry need as well as a belief that the scientist could help, they acted in a cooperative way in order to bring about the consortium. *Rewards* could also be considered a mechanism driving this project. It can be argued that scientists' motivations to fulfil an industry need would mean they were rewarded in terms of fulfilling their own interest in wider societal challenges. Another less predominant mechanism is *altruism*. Altruism refers to helping unselfishly and selflessly by using one's own resources to do something good for another person or group. This principle or practice of unselfish concern for or devotion to the welfare of others can be observed in the scientists' intentions of greater good. However, it is not clear if these intentions are altruistic or not. From a closer investigation of the evidence, it is argued that the predominant action-formation mechanism driving SUSSLE is *self-interest.*

The closer a research leader's personal interest in the topic, the stronger the connection to the project. Self-interest can be defined as "the pursuit of personal advantage, be it money, fame, power, reputation, salvation" (Elster, 2015, pg.68). This self-interest mechanism is exposed by an intrinsic motivation, where the personal benefit arises from the satisfaction of the end product, in this case, providing safer and less wasteful food products. The existence of indirect reciprocity could suggest that scientists behave in a self-interested way in order to develop a reputation. Additionally, it is likely that they also reciprocate in different situations to have opportunities for subsequent rewards.

The motivation to have an impact on wider societal issues and to contribute in a concrete way towards these challenges is a driver for scientists to participate in this project. This mechanism has a consequentialist motivation, in other words, it is oriented towards an outcome of action. In this case, the outcome is safer and less wasteful food manufacturing processes. While the actions are observable – reaching end consumers, fulfilling an industry need, and so on – the motives are not observable. Therefore, the mechanism refers to the motive behind those actions, in this case the motivation to fulfil their personal and professional interest.

Table 27 offers a summary of some of the evidence collected during fieldwork, providing some quotes from the interviewees. They represent the link between evidence and the agency level macro codes, which are the motivations and beliefs. This evidence helps to support the narrative explanation at the agency level, consequently supporting the abstraction to the action-formation mechanism.

Table 27: Finding the action-formation mechanism for knowledge transfer in SUSSLE

FINDING THE ACTION-FORMATION MECHANISM	
EVIDENCE – QUOTES AND SOURCES OF INFORMATION	**AGENCY LEVEL MACRO CODES**
"If you sit in an organization like this (IFR) and many others, you're constantly looking for opportunities for somebody to support your research. That's what everybody is doing all the time, and you want those opportunities to fit what you can do, but also what you would like to do. And gradually, doing things that are likely to have an impact has become much more important for me than doing something that might be really high-quality science but possibly a bit farther from the market. So it was much more of a chance to actually make a contribution to things like that. I knew how valuable shelf life is" (I33P26, pg.3).	*Motivations (opportunities for research, topic fit, contribution)*
"When you can safely extend the shelf life it has a massive effect not just on the profits of the company, but the reduction of waste, environmental concerns about reduced processing and so on. And all of those things are massive and possibly underrated…about a third of all the food manufactured is actually wasted but only a small part is from the consumer. A lot of it is from the manufacturing domain because of	*Beliefs (societal concerns)*

the way they have to satisfy certain regulations in terms of intermediate storage and so on. Understanding that leads to massive reductions in waste and energy usage and reduction in greenhouse gases and all things like that most people don't see" (I33P26, pg.3).	
"Our intentions of working on this project was to reach more the end users if you like. The aim was to present them with a shelf life and heat treatment that they could apply and they are all applying to make their food safe" (I28P13, pg.10).	*Motivations (to reach end consumers)*
"They (food manufacturers) have a problem of getting rid of their waste material. Their aim is to increase their efficiency, reduce waste, reduce energy costs, and this project has done all of those for them" (I28P13, pg.11).	*Motivations (fulfilling an industry need)*
"It worked really well. I enjoyed it because I thought what we were giving industry was what they wanted. It wasn't just us doing what we thought it was a bright idea. That worked well" (I28P13, pg.13)	*Motivations (fulfilling industry needs)*
"The reason why I did this project, well, it's complicated. I think we should, all the research leaders here should run an applied fundamental program of research. That is what I'm trying to do, fundamental research. We do high quality molecular biology; very good stuff we do. And we do applied work, which is mainly with the food industry. We get to learn a lot about what they do, which helps us to do our job much better" (I12P13, pg.6).	*Motivations (knowledge exchange, learning)*
"Generally industry wants very quick and short answers. It's getting that balance, it's very difficult getting the time right. It's a continuous challenge that I have. For me it's a bit of a bonus to have an impact agenda, I think it's really a good idea. I think I average about £350K worth of external funding per year over the last 20 years. That's about 3 people externally funded in my group. I have a difficult balance to maintain but makes external and internal funding work" (I12P13, pg.9).	*Motivations (maintaining research staff)*
"This project is what I thought I should do. And it was what I thought…if I succeed, if I fail. I will do what I think we should be doing" (I23P13, pg.10).	*Beliefs (right thing to do)*
"I'm a mathematician and I've been at IFR for 33 years and now work in areas of food safety risk assessment. In all that time I've always maintained industrial contacts in industry research. So I've worked with many, many companies. Some of the biggest food companies in the world, some small ones as well and continue to do so. I don't think I would ever consider researching without doing this really. I've tried to maintain a balance 50-50 between sort of what I would call applied translational research and what I would call more pure academic type research" (I25P26, pg.1).	*Beliefs (importance of fundamental-applied link)*
"While I was working on mathematical models, somebody introduced me to some mathematical models that were related to bacterial growth. I met a couple of really interesting people, they were quite influential I guess. So, I worked on that for a little bit and gradually got more and more interested. I think when you get older, science in society becomes more relevant to you. You start thinking about issues to do with public health and safety and what's more relevant to me now, it's working closely with Public Health England and people who run risk" (I25P26, pg.2).	*Beliefs (personal interest, social concerns)*

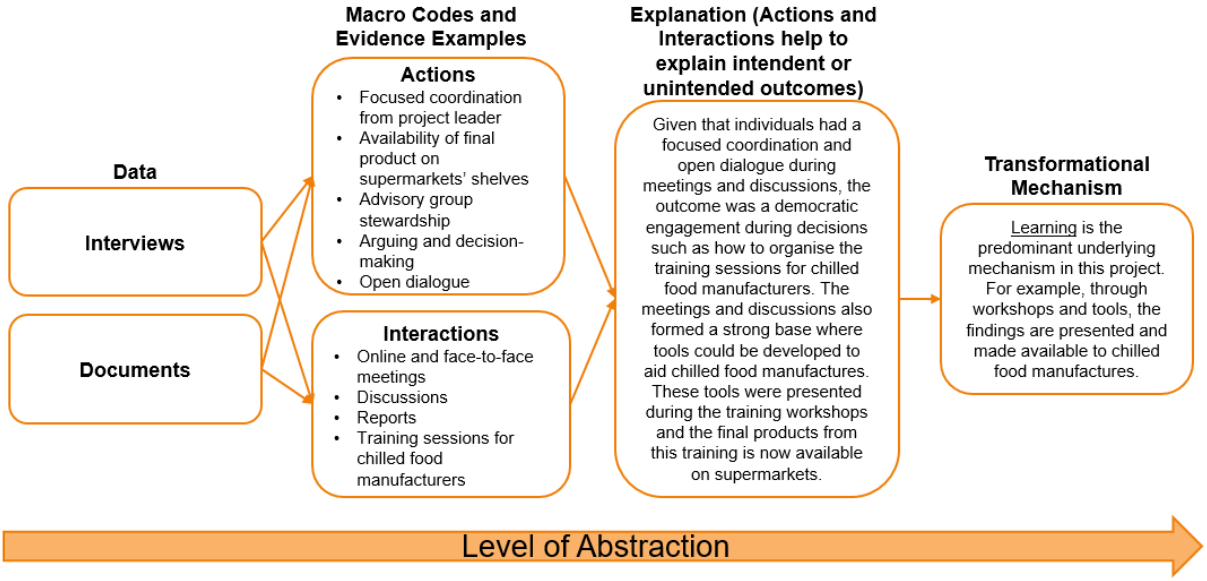
"I know when things are done. I know when products are on the shelf, I can go to a supermarket and point a product on the shelf where something's changed like the shelf life or the level of salt, because of advice I gave to the company. I could also point out at least 2 manufacturing processes where they knocked down their building and rebuilt it because they realised they couldn't perform the tasks they wanted to perform" (I25P26, pg.7).	*Motivations (satisfaction from concrete application)*
"I do still get involved with some purely academic research, but I think the most rewarding stuff that I do is exactly with the people who actually are going to use what I do. If you find somebody who says I do some really high quality academic research but I can't apply they ought not to be doing it. I mean, even if somebody else who has to apply it. You should always see what the end points are" (I25P26, pg.8).	*Motivations (reward)*
"I don't think I've ever started anything without knowing what the end point was. You can't guarantee but you can have a go at it. But just to do something because it's there I mean I'm sure that's not a good use of time really" (I25P26, pg.9).	*Beliefs (meaningful research)*
"I'm still entrenched in why we see it as food business, I much more think about it as the food climate for the food experience. It actually involves all kinds of food safety, has societal impact, political impact, economic impact. These are just as important as finding a way to extend shelf life on some products and therefore reduce the amount of waste" (I25P26, pg.10).	*Beliefs (societal impact)*
"I think the sort of stuff that I do is, a big part of it is an appreciation for the scale of food production. You transfer the care that you might take if you were making one particular thing for yourself to eat. How do you transfer that level of care to do it for 20 million people" (I25P26, pg.19).	*Beliefs (scalability)*
"IFR actually does science and other places are more commercial testing labs and it's not really pure science, at least I don't conceive it like that. We want fundamental research, not just shuffling information around that we already have" (I32P30, pg.3).	*Motivations (importance of fundamental science)*
"For me, companies always know what they want and within the company there's usually someone, not necessary the CEO, who has the technical ability to put things together that they need. So I would go and find that guy and talk to him because usually they are an amazing source of information" (I25P26, pg.7).	*Motivations (providing useful research)*

6.3.3 TRANSFORMATIONAL MECHANISM IN SUSSLE

The transformational mechanism relates to the explanation of an outcome, the interaction and aggregation of individual actions. By describing how individual actions produce various outcomes – intended or not – it is possible to form a narrative that is related to how project partners made different decisions that produced outcomes such as dissemination and engagement. Therefore, there is an interdependence among the actions, interactions and outcome. The SUSSLE project had a predominant transformational mechanisms of learning,

as summarised in Figure 20. The following sections will provide a detailed explanation of how the analysis was achieved from the data through the mechanisms.

Figure 20: Transformational Mechanism in SUSSLE



The interaction of actors involved in the SUSSLE project involved regular meetings – face-to-face and online, where discussions on dissemination routes, guidelines and directions of next steps were made. These meetings did not involve any kind of formal voting but a constant dialogue among project members, as shown with an extended version of the evidence in Table 28:

> *"Decisions were made by discussing with stakeholders during the meetings, there was no consensus, only discussion. For example, anything that is published has to get the full permission of the consortium" (I33P26, pg.5).*

The project also benefited from a strong coordination from the CFA's director, who had an understanding of the industry's need and maintained a focus among the research leaders:

> *"Karin was very good. She drove that project home really well. She's excellent. It's a shame she can't get involved in more projects. She's so good at keeping you focused and yet still moving forward" (I33P26, pg.1)*

The findings from the project work were shared among the project members during meetings and also via reporting. These events provided an opportunity for actors to present their work and also to learn from each other. However, results from the project were only accessible to CFA members, who were the direct beneficiaries, via workshops and training sessions which

were regularly provided by IFR. These sessions were free to attend and all chilled food manufacturers that are CFA members were invited to attend. During these sessions, results from the project were presented and s of different tools were given so that individual companies can utilize them:

> *"We have a series of technical training sessions for CFA members that are still going on. Some of them here (IFR) and others in Kettering. So Mike and I give an afternoon where we talk about how the project went and what the results were. I demonstrate some software tools that we generated during the project and how they can use them in their business" (I33P26, pg.6).*

> *"We've been running implementation workshops together: what the activities were, what the findings were and how to implement them. I drafted the implementation guidance" (I32P30, pg.2).*

The success of the workshops meant that food manufacturers learned and used new processes in their business, resulting in safer end products to consumers. It also provided less wastage during the manufacturing process:

> *"It's possible to go into a supermarket and find a product that has the science applied" (I33P26, pg.7).*

There are some mechanisms that could be abstracted from this evidence, for example, *coordination, interdependency* and *learning*. The mechanism of *coordination* could be explained by the interaction of actors, being face-to-face or online, which involved discussions and decisions. It could be argued that these interactions were successful due to a coordination mechanism underlying the events. Another mechanism that helps to explain the outcomes, particularly the one related to consumer reach, is *interdependency*. This interdependency relates to the different actions that depend on each other. In SUSSLE, the various meetings and discussions brought about decisions on the directions of the project and how they would disseminate the results to food manufacturers and the wider communities. Nonetheless, from the evidence it is argued that the predominant transformational mechanism within SUSSLE is *learning*.

Learning is a process where individuals absorb something new that they did not know before. In this project, it took form in two ways (1) during the meetings, where scientists and industry leaned from each other, and (2) during the training workshops offered to food manufacturers. The outcome intended during these actions and interactions is to translate the findings of the project into a digestible and useful tool for food manufacturers. Although the interaction of

actors within SUSSLE is done through discussions and arguing, the underlying mechanism that translates those decisions into practice take form during the training workshops provided to CFA members. Through a learning mechanism, the results from the project are absorbed by food manufacturers in the workshops and training sessions where there is an interaction with research leaders from IFR.

Interactions take many forms, and an outcome depends on the outcomes for others. In the case of SUSSLE, research leaders were motivated by their self-interest of having their science utilised to produce safer and less wasteful products. Because of their reputation and capabilities, they managed to produce specific tools that could be used by food manufacturers. These tools were the first outcome of this project. The next step, which is where the learning mechanism takes place, is related to how these tools were introduced to food manufacturers. This introduction was done via workshops and training programs, where the tools were learned and tailored to various food manufacturers. From applying these novel processing methods, food manufactures were able to produce safer and less wasteful products, which are now on supermarket shelves. These products are the final outcome desired by the research leaders.

Table 28 offers a summary of some of the evidence collected during fieldwork, providing some quotes from the interviewees. They represent the link between evidence and the interaction level macro codes, which are the actions and interactions. This evidence helps to support the narrative explanation at the interaction level, consequently supporting the abstraction to the transformational mechanism.

Table 28: Finding the transformational mechanism for knowledge transfer in SUSSLE

FINDING THE TRANSFORMATIONAL MECHANISM	
EVIDENCE – QUOTES AND SOURCES OF INFORMATION	**INTERACTION LEVEL MACRO CODES**
"Karin was very good. She drove that project home really well. She's excellent. It's a shame she can't get involved in more projects. She's so good at keeping you focused and yet still moving forward" (I33P26, pg.1).	Actions (focused coordination)
"There were regular meetings, probably more than 20. In actual fact we had an external advisory group as part of the project and we used to meet. Now the guy moved to Australia which meant the meetings are now done by Skype…myself, Mike, Karin and the people from Unilever would get in a room and would talk to the external people by Skype" (I33P26, pg.4).	Interactions (meetings face to face and online)
"The project had a management arm, which were those sort of meetings (Skype), but also we continually met with stakeholders of various kinds, particularly the Chilled Food Association members" (I33P26, pg.4).	Interactions (meetings)
"Decisions were made by discussing with stakeholders during the meetings, there was no consensus, only discussion. For example, anything	Interactions

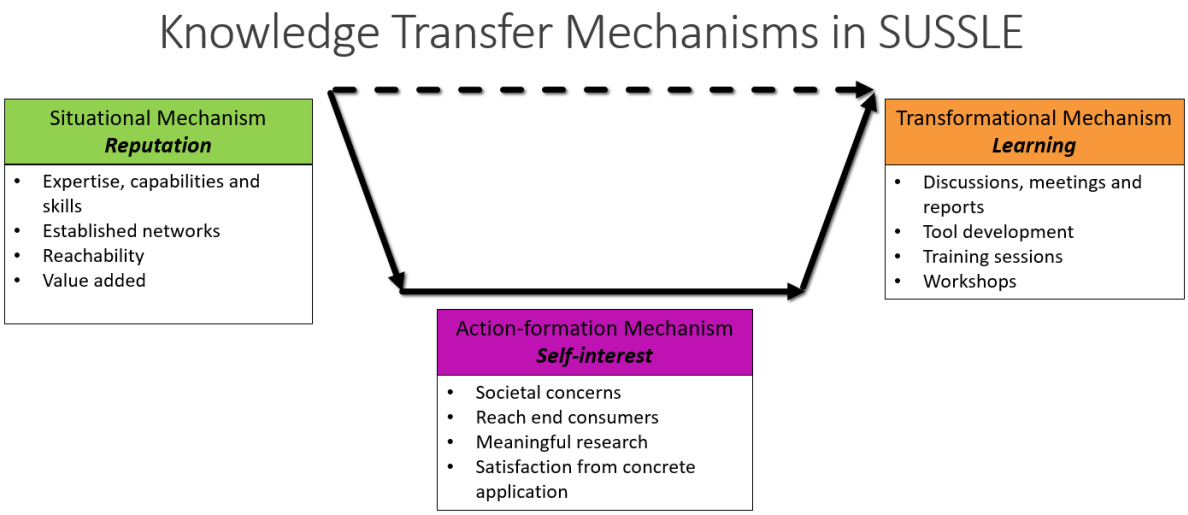
that is published has to get the full permission of the consortium. I constantly wrote reports. So there are 12 internal reports that I wrote that are only accessible by the management in the project." (I33P26, pg.5).	(discussions, reports)
"We have a series of technical training sessions for CFA members that are still going on. Some of them here (IFR) and others in Kettering. So Mike and I give an afternoon where we talk about how the project went and what the results were. I demonstrate some software tools that we generated during the project and how they can use them in their business" (I33P26, pg.6).	Interactions (training sessions)
"The companies who are members who know about these sort of projects and know what advances it can bring. There are conditions on using the results and so forth because you have to do it according to our guidelines. So there are written guidelines but the only way to get permission to use it is to attend one of these training sessions. Each company then decides who comes along and benefits from it. So they will send 6 or 7 people and technical people from different factories depending on the size of the company. They learn about the science behind it and the training in the software tools that we developed" (I33P26, pg.6).	Interactions (guidelines, training)
"It's possible to go into a supermarket and find a product that has the science applied" (I33P26, pg.7).	Actions (final product)
"We have an advisory group that met and discussed decisions. For example, in the paper we've just published, we wanted to determine the number of spores of Clostridium botulinum in the raw materials. So we looked at literature data, combined all of it together then did some tests of our own…and they varied so one decision we had to made was to put the raw materials into different categories. So this international advisory group went through everything and put them into different categories, ending up with 9 groups" (I28P13, pg.6)	Actions (aggregation, advisory group)
"If we needed to make a decision we argued until we came to a conclusion. There was a lot of arguing, not unpleasant arguing. It's the discussions between, in general terms the industry, Gary and myself. The ability of all of us to discuss things in an adult way where we don't agree was the key to the success. By having those discussions and being brutally honest with each other we were able to take it forward in a way that none of us could have done on our own" (I28P13, pg.12,13).	Actions (decision-making, arguing)
"We've been running implementation workshops together: what the activities were, what the findings were and how to implement them. I drafted the implementation guidance" (I32P30, pg.2).	Actions (workshops)
"There was reporting at every technical and executive meeting of the association, which was 36 meetings and a lot of time with the project and members" (I32P30, pg.2).	Actions (reporting)
"We've always had a very open and ongoing dialogue. I'm the only one that was on the expert group and the management group, so it's very close involvement" (I32P30, pg.3).	Interactions (dialogue)
"Instead of IFR talking to companies individually they can come to the CFA and we will talk about the chilled food industry. When it's fundamental research, they come to the association. Or if there is a big industry wide	Actions (fundamental research)

issue and it requires a lot of coordination, they talk through to the CFA" (I32P30, pg.4).	
"We just had a paper accepted describing the work done at SUSSLE, which is concerned with spore loads in foods" (I28P13, pg.3).	Actions (dissemination)

6.3.4 *Summary of SUSSLE*

There are three predominant mechanisms affecting knowledge transfer at SUSSLE: *reputation, self-interest and learning* as summarised in Figure 21. Having the scarce expertise to fulfil an industry need and established networks with key industrial players, allowed research leaders at IFR to put together a successful proposal. Driven by a *reputation* mechanism, these resources made it possible for scientists to fulfil their motivation to eventually reach end consumers with their science. A concern with wider societal challenges and a motivation to achieve meaningful research was motivated by a *self-interest* mechanism. This mechanism drives a long-term, value informed quest that goes beyond short-term rewards. The outcome of producing less wasteful and safer products was achieved by producing tools that were offered to food manufacturers through a *learning* mechanism.

Figure 21: Knowledge transfer mechanisms in SUSSLE



6.4 Regulation Driven Project: Nutritional Information Solutions (NIS)

6.4.1 *Background*

The Nutritional Information Solutions (NIS) project was launched by IFR in January 2016 with the mission to provide legally compliant nutrition labels at affordable cost. The aim is to provide nutritional label information from products' recipes as an alternative to expensive laboratory compositional analysis. This calculation of nutrient content is cost-effective and quick but can

be difficult for food companies, particularly SMEs, that have little or no knowledge of nutrition and food composition.

Scientists from IFR have drawn from their expertise in the production of the UK composition of foods datasets and nutrition knowledge to develop this system. IFR have created and own both McCance and Widdowson databases, which sit within Food Databanks at IFR. Food Databanks is a department within IFR and is also a national capability supported by BBSRC. A national capability is a BBSRC-funded resource intended to benefit the scientific community in general. These can be facilities as well as open-source datasets. The aim of these capabilities is to allow the UK to deliver world-leading science, to support national strategic needs, and to respond to emergencies in various scientific areas. BBSRC funds very few national capabilities, which are hosted and maintained at Institutes, and Food Databanks is one of them. Therefore, this resource is vital for IFR as it offers not only a national status, but works as an important funding stream.

The Food Databanks national capability manages data on the composition of foods consumed in the UK. As well as providing the nutritional information for food labelling, this data underpins research at the IFR, across Europe and beyond into the links between diet and health whilst helping to inform policy to promote a healthy lifestyle (IFR, 2016). Food Databanks oversees two different, but interconnected, databases, drawing on IFR's years of experience in developing and maintaining information resources on the nutritional content of food. The nutrient composition for UK foods database describes foods eaten in the UK in terms of their macronutrients, e.g. fats, protein, carbohydrates as well as their micronutrient content, which includes vitamins and minerals. The eBASIS is another database developed by IFR of non-nutrient bioactive compounds with putative health benefits.

Using the recipe information that food producers provide, NIS is able to calculate and produce the nutritional labelling required from different ingredients. Where additional nutritional information is needed for ingredients such as vitamins and minerals, they are uniquely placed to obtain that information. The rationale behind the NIS project is to launch a commercially viable and sustainable service that will be a new business commercial division within IFR. This business will market to UK SMEs and utilise IFR's and Food Databanks' proprietary skills, knowledge and resources, to create a sustainable income stream. This service costs one fifth of traditional laboratory compositional analysis of ingredients. NIS was developed by Food Databanks' scientists and it reports to the IFR strategy board, which is composed of senior executives from IFR and from the Norwich Research Park (NRP).

Norwich Research Park (NRP) comprises over 50 businesses, 3,000 scientists, researchers and clinicians (Park, 2016). It includes, among others, the University of East Anglia (UEA), the John Innes Centre, IFR, The Earlham Institute, The Sainsbury Laboratory, and Norfolk and Norwich University Hospital. Apart from facilitating collaboration and engagement within the Park, one of the aims of NRP is to support the commercialisation of science. It offers several funding opportunities such as translational funding, a science links seed fund, an impact fund, and a proof of concept fund. NIS originally applied for and received proof of concept funding, which is the fund that helps to accelerate the development of promising ideas and inventions which have commercial potential.

6.4.2 SCOPE CONDITIONS

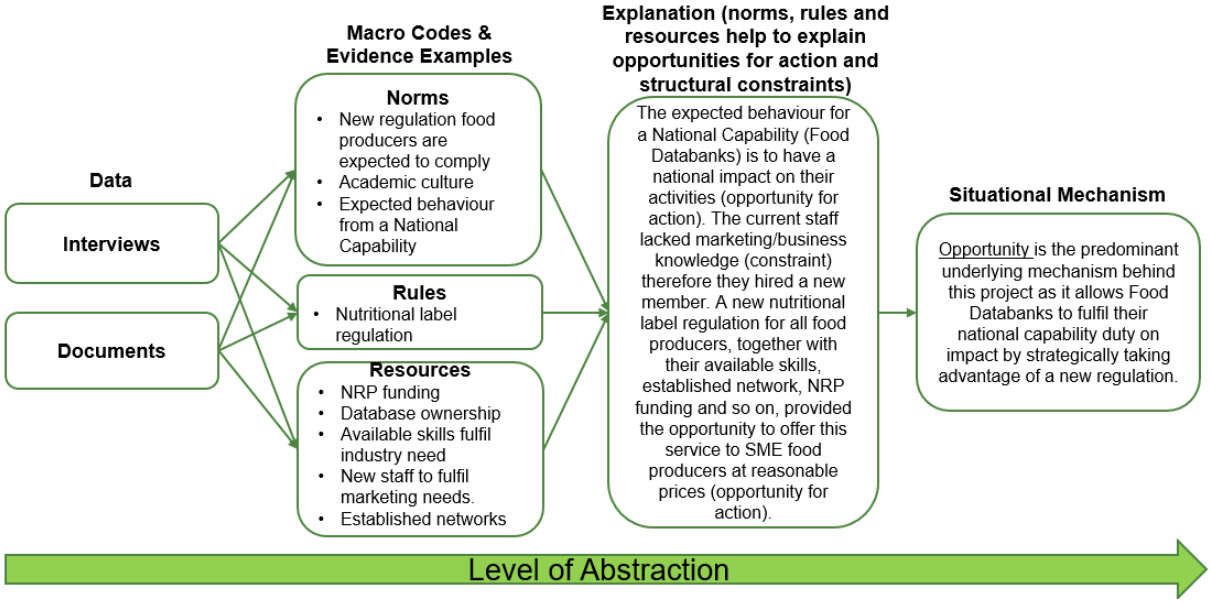
The new EC Food Information Regulations (EU 1169/2011), which includes nutritional information started on 13th December 2014 and became mandatory from 13th December 2016, replacing the previous food labelling regulations. DEFRA (Department for Environment Food & Rural Affairs) guidance states that data from McCance and Widdowson's datasets can be employed for this purpose.

Food producers must comply with the new legislation by specifying all nutrients on their packaging. The nutritional food labelling must display all the nutrients and allergens on the packaging. The information on the packaging must be clear and easy to read, easy to understand, not misleading and must show the following information: a) energy value (in both kilojoules (kJ) and kilocalories (kcal)); and b) the amounts (in grams (g)) of fat, saturates, carbohydrate, sugars, protein and salt. There is a voluntary declaration for supplementary nutrients such as mono-unsaturates, polyunsaturates, polyols, starch, fibre, vitamins and minerals.

6.4.3 SITUATIONAL MECHANISM IN NIS

The situational mechanism is related to the structural side of the projects, including norms, rules, and resources that will help to elaborate the structural constraints and opportunities, in other words, the macro influence on more micro behaviour. A meaningful explanation is context-bound therefore it is important to be reconstructed from within the project, by playing close attention to local dynamics. The NIS project had a predominant situational mechanism of opportunity, as summarised in Figure 22. The following sections will provide a detailed explanation of how the analysis was achieved from the data through the mechanisms.

Figure 22: Situational Mechanism in NIS



IFR's Food Databanks have the responsibility to show a national impact on the work they undertake in order to keep their national capability status and funding from BBSRC, as shown with an extended version of evidence in Table 29. This responsibility can be illustrated as follows:

> *"We (Food Databanks) as a group because we are a national capability, we have to be seen to be helping nationally this cause, the whole impact agenda…we have the sort of public engagement about everything we do…" (I29P28, pg.16).*

A new regulation on nutritional labelling is a key example of a nationwide regulation that created the opportunity for IFR, and in particular Food Databanks, to provide a service of wide reach. By creating and owning the datasets that contain all nutritional information for different foods, and by securing additional funding from Norwich Research Park (NRP), Food Databanks were able to establish an innovative service at affordable prices for SMEs, which otherwise would be financially prohibitive for them:

> *"We produce these composition of foods, 3000 foods, and all the nutrients composition. It's like a bible of what is in the food we eat, and because we produce it, we have to find other things to do with it. The new regulation coming in end of 2016 says all producers of food need to have a nutrition label on their food" (I29P28, pg.13).*

> *"Nutritional Information Solutions comes from funding around the impact to actually prove the concept. We've had some funding from NRP (Norwich Research Park) in terms of translation fund to actually set this up and get it moving" (I31P29, pg.1).*

> *"In the UK, 60% of food producers have already put nutrition labels on their food products. Because we have a very polarised retail market, they force it down their supply chain. However, there is a 40% who don't, that's actually quite a lot. They are the 40% that can't afford compositional analysis" (I31P29, pg.1).*

Some regulations could engender conflicts. SMEs did not always view this new regulation as a positive impact on their business:

> *"I'm afraid the nutritional information we had to pay for and get for our products was more of a forced legality by the government than a need to know the information, I'm afraid 99% of the public aren't interested either as hardly anyone turns the product around to read this information before they buy" (food producer, I39P36, pg.1).*

Another key resource available within IFR is their vast network of established contacts, which not only gave them the opportunity to reach SMEs, but also for SMEs to learn about them, as illustrated in the following quotes:

> *"The most powerful thing we've found so far is going via the networks that SMEs belong to, and because of that endorsement, almost like a third party endorsement, they trust it. Because this is disruptive in the nature of the service or product, you almost take out the problem with having to convey what it is. So far, in terms of cost of acquisition, that's the cheapest" I31P29, pg.10).*

> *"I was a founding member of Proudly Norfolk and heard about this service from them, I haven't worked with IFR before" (food producer, I39P36, pg.1).*

There was a lack of internal business acumen and staff with considerable business experience. This created a constraint in terms of carrying on with the project. The NIS project moved forward by recruiting someone with business and marketing experience:

> *"Mike is coming to market NIS, because obviously we are a bunch of scientists, so we are not marketing people. We know it will work but he has had to come in to work out this website and all that sort of stuff" (I29P28, pg.14).*

There are a few mechanisms that could be abstracted from the evidence investigated, such as *institutional, network* and *opportunity*. It could be argued that the project was driven partly by an *institutional* mechanism. Being a national capability, the Food Databanks within IFR has the responsibility to follow a strict agenda regarding industry engagement and commercialisation. This agenda, together with the strong impact agenda imposed on IFR, has been driven by institutionalised norms and duties that the scientists must observe in order to maintain and gain funding. Similar to the previous projects, it could also be argued that the project was driven by a *network* mechanism. It was through IFR's established network and the new development manager's network, that they could reach SMEs, as well as SMEs being made aware of their existence.

Nevertheless, the evidence points to a predominant situational mechanism of *opportunity*. Opportunity is "the conscious policy or practice of taking advantage of circumstances" (Barney and Hesterly, 2012, pg.185). For example, the goal was to have wide impact in the food industry. The external regulation offered the opportunity for Food Databanks to fulfil their national capability duties on the impact agenda. By taking advantage of their datasets, using current scientists and hiring a business development manager, they were able to strategically use this opportunity to their advantage.

The nutritional label regulation can be interpreted as a prescriptive rule in both origin and function. The regulation has been established by the UK government from an EU law, and it is intended to ensure compliance from all food producers. These food producers are expected to conform and apply the new standards quasi-automatically, with the consequences of their products being removed from trading if compliance is not achieved. Although this new regulation does not directly affect IFR, they do work with food producers on a regular basis. The food producer SMEs did not embrace such regulation, but must comply to it to remain in business. However, they would not have been able to afford the traditional compositional analysis. The opportunity mechanism can be abstracted from the evidence and comes across strongly in the case of NIS.

Table 29 offers a summary of some of the evidence collected during fieldwork, providing some quotes from the interviewees. They represent the link between evidence and the structural level macro codes, which are the resources, norms and rules. This evidence helps to support the narrative explanation at the structure level, consequently supporting the abstraction to the situational mechanism.

Table 29: Finding the situational mechanism for knowledge transfer in NIS

FINDING THE SITUATIONAL MECHANISM	
EVIDENCE – QUOTES AND SOURCES OF INFORMATION	**STRUCTURE LEVEL MACRO CODES**
"I was a founding member of Proudly Norfolk and heard about this service from them, I haven't worked with IFR before" (food producer, I39P36, pg.1).	*Resources (network)*
"I've hear about NIS through a business network that I belong through a third party organisation" (food producer, I42P39, pg.1).	*Resources (network)*
"Nutritional Information Solutions comes from funding around the impact to actually prove the concept. We've had some funding from NRP (Norwich Research Park) in terms of translation fund to actually set this up and get it moving" (I31P29, pg.1).	*Resources (funding)*
"I'm afraid the nutritional information we had to pay for and get for our products was more of a forced legality by the Government than a need to know the information, I'm afraid 99% of the public aren't interested either as hardly anyone turns the product around to read this information before they buy" (food producer, I39P36, pg.1).	*Norms (expected to comply)*
"The European Union has brought in some new nutritional label laws. They came about in 2011 and in December this year, 2016, they come into force. So every prepacked food producer has to produce a nutritional label. So we have taken the opportunity with that knowledge about food ingredients and nutrition to bring out a new supportive service that provides nutrition label inexpensively, just from our product recipe via calculation" (I31P29, pg.1).	*Rules (nutritional label regulation)*
"In the UK 60% of food producers have already put nutrition labels on their food products because we have a very polarised retail market, they force it down their supply chain. However, there is a 40% who don't, that's actually quite a lot. They are the 40% that can't afford compositional analysis" (I31P29, pg.1).	*Rules (nutritional label regulation)*
"The 60% from the big UK retailers, we are already having conversations, which has surprised us, with a couple of big retailers who are finding it very expensive to get their suppliers to comply with the traffic light information. They are quite interested in working with us to do a desktop calculation for their supply chain to check the traffic lights" (I31P29, pg.2).	*Resources (available skills, fulfilling industry need)*
"We own the datasets that we use to get this information. We built in a checking process. Jenny comes along and checks the work that Hannah's got. Mark is the expert in nutrition so he is a great reference point for all of us. Olivia keeps track of all checkpoints and makes sure that we actually deliver. And of course there's Paul, the king of nutrition in Europe and Reg in terms of where we're going with the business strategically" (I31P29, pg.3).	*Resources (available databases and skills)*
"The original proof of concept started probably 12 months ago. It would be pointless investing if we couldn't validate what the outcome was. And interestingly we are now using that information with a major retailer who are quite intrigued that they could save themselves and their suppliers a fortune by using computational analysis rather than compositional analysis" (I31P29, pg.4).	*Resources (available skills)*

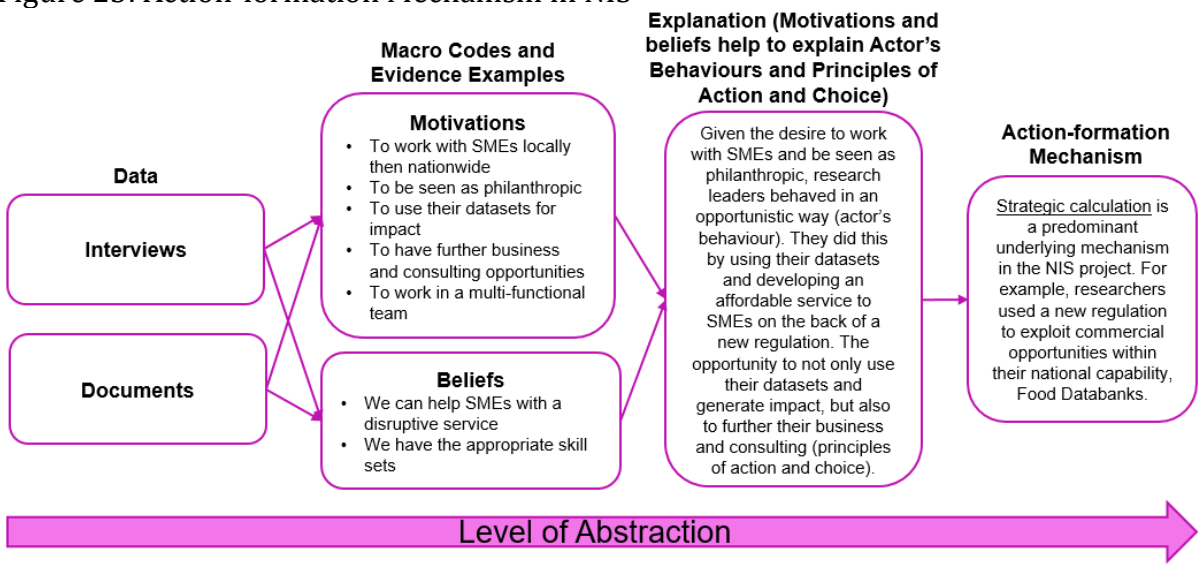
"We had some problem with the admin costs in terms of manual invoicing and all that. They are not (IFR) a culture of commercial, they are a culture of academia. So, you know, that's a challenge" (I31P29, pg.4).	*Norms (academic culture)*
"The idea for this business came from Food Databanks (within IFR) and we had initially £47K translation fund to get the proof of concept" (I31P29, pg.6).	*Resources (funding)*
"The contractual relationship with the customer over the website, there was a problem with that as well because you're dealing with the organisational culture, and, you know, not understanding that this is a business. It's got to move quickly. It's good to be agile, but when you explain that to people, they are so great here, they just go straight into it. You just have to explain, they are such intelligent people" (I31P29, pg.8).	*Norms (organisational culture)*
"I've worked at the Norfolk County Council; they gave me a database of SMEs that they use. So we've gone out to that with a direct marketing campaign. The brochure has gone out and I'm now about to start the phoning round" I31P29, pg.9).	*Resources (available contacts network)*
"The most powerful thing we've found so far is going via the networks that SMEs belong to, and because of that endorsement, almost like a third party endorsement, they trust it. Because this is disruptive in the nature of the service or product, you almost take out the problem with having to convey what it is. So far, in terms of cost of acquisition, that's the cheapest" I31P29, pg.10).	*Resources (available contact network, credibility)*
"We produce these composition of foods, 3,000 foods, and all the nutrients composition. It's like a bible of what is in the food we eat, and because we produce it, we have to find other things to do with it. The new regulation coming in end of 2016 says all producers of food need to have a nutrition label on their food" (I29P28, pg.13).	*Resources (available databases and skills)*
"Mike is coming to market NIS, because obviously we are a bunch of scientists, so we are not marketing people. We know it will work but he has had to come in to work out this website and all that sort of stuff" (I29P28, pg.14).	*Resources (new available skill, staff)*
"We recruited Mike because we wanted somebody that had a food industry background. He came with both the food background and also financial background. He was in marketing as well so it's like a perfect combination of things" (I30P8, pg.9).	*Resources (new available skill, staff)*
"One of the things we had to demonstrate as a national capability was how to get money and value out of what Food Databanks has done. This idea provided not only an income but also a direct impact for the food industry. It allowed the consumer to have more information through food labelling, the industry has access to a cost-effective labelling service, so there are both industrial and societal impact." (I43P16, pg.1).	*Norms (expected behaviour of a national capability)*
"We as a group because we are a national capability, we have to be seen to be helping nationally this cause, the whole impact agenda. So the fact that we can now go to food fairs and things like that where we talk, where we have the sort of public engagement about everything we do, and this is where we can help. So, we have the crossover between being a scientist" (I29P28, pg.16).	*Norms (expected behaviour of a national capability)*

"We did this partly because there was a commercial opportunity but partly because BBSRC said you need to do something commercial that has an impact. Would we have done it without their pressure? We might have but not necessarily…" (I43P16, pg.1).	*Norms (expected behaviour of a national capability)*
"Legislation was moving into the direction which was going to require all food producers to have nutritional labelling on their packages. Ideally what legislators would like, would be that every recipe that you made would go off and have a chemical analysis. Food Standards Agency recognised that this would be prohibitively expensive for food manufacturers, especially SMEs to follow this new regulation. Use NIS as alternative – based on the percentage calculation of each individual ingredient is possible to provide an accurate nutritional content. It is a complicated process because you not only need to do a calculation but you have to have access to the compositional information for the specific ingredient." (I43P16, pg.2)	*Resources (available skills, fulfilling industry need)*

6.4.4 *Action-formation mechanism in NIS*

The action-formation mechanism seeks to explain actors' behaviour and choice, for example, given the structural conditions they are under, do they act in a rational way, in a value seeking way, by impulse, and so on. Ultimately it looks for an explanation as to why people act given their motives and situations, ranging vastly between rational and logical to impulsive and visceral motives. The NIS project had predominant action-formation mechanisms of strategic calculation, as summarised in Figure 23. The following sections will provide a detailed explanation of how the analysis was achieved from the data through the mechanisms.

Figure 23: Action-formation Mechanism in NIS



One of the motivations to participate in the NIS project is to be able to commercially exploit their datasets to generate impact, as shown with an extended version of the evidence in Table 30. One example of this motivation can be seen from the following quote:

> *"The project idea came about for two reasons, one we were sort of looking for opportunities to exploit some of the knowledge and data that we have. That was sort of driven by the national capability and what it should be doing. Then there is the need in terms of labelling with the regulations changing we knew that SMEs were in need of help" (I30P8, pg.8).*

Another driver for their motivation is the opportunity to work with local food producers and potentially expand nationwide. Due to their strong network links, the scientists believe that they can expand fairly swiftly, which would make the project sustainable in the long term.

> *"The sad thing is that many SMEs will have obsolete packaging if they are not thinking about it, and again, this is my passion for SMEs, I want to help them" (I31P29, pg.10).*

The scientists' also hold a belief that the service this project offers can be seen as philanthropic to some SMEs, which so far have been struggling to comply with the new nutritional label regulation due to the extreme high cost of laboratory compositional analysis:

> *"The nice thing is that we're seen as philanthropic when we approach these businesses because they are desperate, they need help." (I31P29, pg.2).*

There is also a strong belief among the scientists and the business development manager, that this is a disruptive service with a sustainable future business model. They trust that NIS offers a disruptive service in terms of how the nutritional analysis is done, which is via recipes rather than laboratory analysis. This in turn offers a much more cost effective service to SMEs:

> *"We're offering a disruptive product. It's disruptive in terms of price, and composition analysis. We manage the datasets, we work with the datasets, we know them so we have some competitive advantage in terms of data" (I31P29, pg.3).*

> *"10-15% of every business develops new products. So we're going to have regeneration from that through traffic light labels, and that's a natural extension from nutrition labels. And then there's formulation. So when they find out they are in red, do they want some consultancy to help them get in amber or green?" (I31P29, pg.7).*

There are some mechanisms that could be derived from this evidence, for example, *reward, self-interest* and *strategic calculation*. It could be argued that IFR scientists were motivated by a *reward* mechanism. Because there was a need for a more cost-effective nutritional analysis,

scientists used this opportunity not only to fulfil this industry need but also to fulfil their own impact statement for the national capability. This meant they were driven by a reward mechanism to secure their status and funding. Another mechanism that could be abstracted from the evidence is *self-interest*. By pursuing to work locally with SMEs, scientists were driven by a self-interest mechanism that would enable them to be seen as philanthropic as well as offering an attainable service.

Nevertheless, from a closer investigation of the evidence, it is argued that the predominant action-formation mechanism driving NIS is *strategic calculation*. This approach assumes a process characterized by exogenous, self-interested preferences and instrumentality (Schimmelfennig, 2005). Strategic calculation also relates to a general plan that is created to achieve a goal. In this case scientists used a new regulation to exploit commercial opportunities within their national capability, the Food Databanks.

Having the ownership of the datasets and the skill sets to provide this service to food producer SMEs promoted a belief that they are offering a disruptive product. This belief was fuelled by their own motivation to help SMEs and being seen as philanthropic, which is a very external way of being perceived. There is also an assumption that SMEs find compositional analysis prohibitively expensive, which could be true in some cases. All these assumptions, beliefs and motivations have geared the scientists and the business development manager to strategically position their business model and take action to create exposure, rapport and repeat business. They have used their available skills and the datasets as an instrument to fulfil their motivations to work with SMEs, to have repeat business, to be seen as philanthropic, and so on.

Table 30 offers a summary of some of the evidence collected during fieldwork, providing some quotes from the interviewees. They represent the link between evidence and the agency level macro codes, which are the motivations and beliefs. This evidence helps to support the narrative explanation at the agency level, consequently supporting the abstraction to the action-formation mechanism.

Table 30: Finding the action-formation mechanism for knowledge transfer in NIS

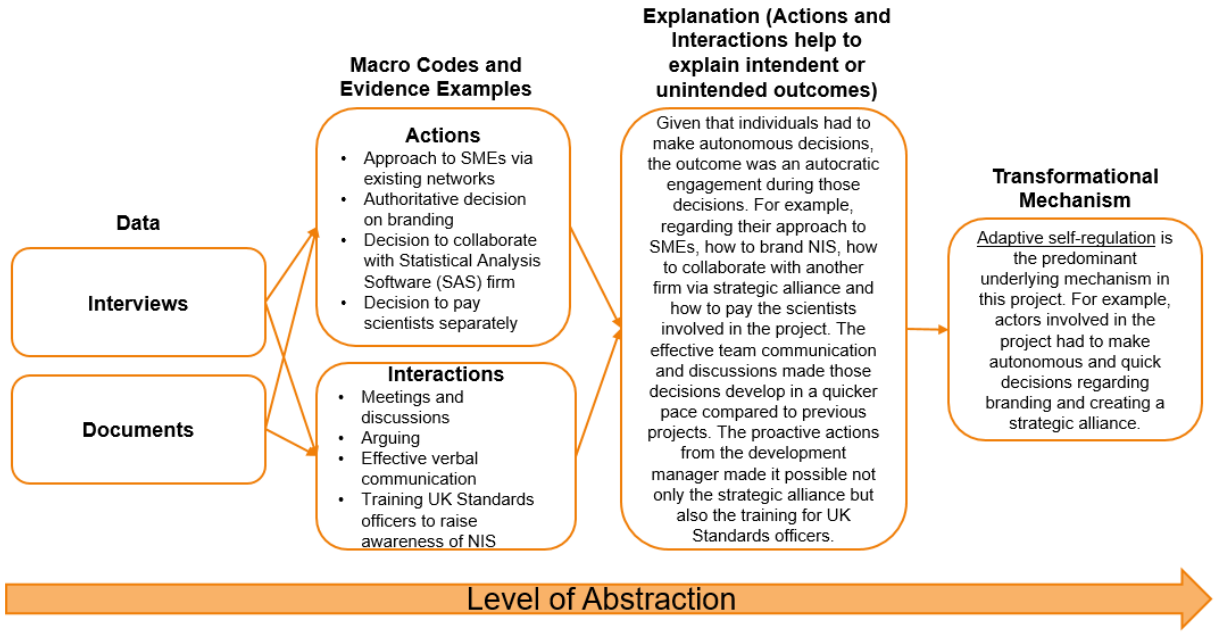
FINDING THE ACTION-FORMATION MECHANISM	
EVIDENCE – QUOTES AND SOURCES OF INFORMATION	**AGENCY LEVEL MACRO CODES**
"I spend most of my life, at the moment, in Shoreditch in London. I only work here 20 hours a week, although it's been about 30 hours a week. I've spent my whole life on aeroplanes around the world and I made the conscious decision last year that I wanted to do things locally, and I have a huge passion for small businesses" (I31P29, pg.12).	Motivations (stay local, work with SMEs)

"The nice thing is that we're seen as philanthropic when we approach these businesses because they are desperate, they need help. What we were concerned about was, what the reaction was going to be, and could gear up the business with the infrastructure and cope demands that we got" (I31P29, pg.2).	Motivations (seen as philanthropic, helping SMEs)
"We're offering a disruptive product. It's disruptive in terms of price, and composition analysis. We manage the datasets, we work with the datasets, we know them so we have some competitive advantage in terms of data" (I31P29, pg.3).	Beliefs (conviction they can help with a disruptive service)
"IFR was looking for someone to help launch the business and manage the business process. I thought "that sounds exciting" so it's a start for me" (I31P29, pg.5).	Motivations (manage NIS)
"I have another income so I don't need a full time job. I can now pick on what I think are exciting projects where I've got the skill set to help, and this is kind of a multi-functional team as well, because obviously we're reliant on the expertise of the scientists" (I31P29, pg.9).	Motivations (having the appropriate skill set)
"The sad thing is that many SMEs will have obsolete packaging if they are not thinking about it, and again, this is my passion for SMEs, I want to help them" (I31P29, pg.10).	Motivations (help SMEs)
"The project idea came about for 2 reasons, one we were sort of looking for opportunities to exploit some of the knowledge and data that we have. That was sort of driven by the national capability and what it should be doing. Then there is the need in terms of labelling with the regulations changing we knew that SMEs were in need of help" (I30P8, pg.8).	Motivations (industry need, available skills)
"We decided there was a niche in the market where we can help these SMEs sort out their nutrition labelling because they don't know what they're meant to be doing. Because we produce this and we understand how the tables work, and because we discussed with the trading standards, it has been agreed that you can calculate what is in the food you eat by using recipes" (I29P28, pg.13).	Motivations (industry need)
"We are working towards developing a stand-alone operation that would do the labelling service for small companies' initially in Norfolk and Suffolk but then nationwide. If it works well we'll make it a stand-alone operation. (I30P8, pg.9).	Motivations (wider reach)
"10-15% of every business develops new products. So we're going to have regeneration from that through traffic light labels, and that's a natural extension from nutrition labels. And then there's formulation. So when they find out they are in red, do they want some consultancy to help them get in amber or green?" (I31P29, pg.7).	Motivations (provide a business with the intended outcome for further business)
"The business rationale is to launch a commercially viable and sustainable service that will springboard a new business commercial division or entity. This entity will market to UK SMEs, piggy backing the brands of IFR and Food Databanks and their proprietary skills, knowledge and resources, to create a future sustainable income stream" (NIS Business Plan, pg.1)	Motivation (create sustainable business)

6.4.5 *TRANSFORMATIONAL MECHANISM IN NIS*

The transformational mechanism relates to the explanation of an outcome, the interaction and aggregation of individual actions. By describing how individual actions produce various outcomes – intended or not – it is possible to form a narrative that is related to how project partners made different decisions that produced outcomes such as dissemination and engagement. Therefore, there is an interdependence among the actions, interactions and outcome. The NIS project had a predominant transformational mechanism of adaptive self-regulation, as summarised in Figure 24. The following sections will provide a detailed explanation of how the analysis was achieved from the data through the mechanisms.

Figure 24: Transformational Mechanism in NIS



The interactions of actors involved in the NIS project involved regular meetings in the beginning, when there were discussions around the purpose of the project and funding streams. However, as the project evolved, meetings became sparser and independent decisions emerged, as show in an extended version of evidence in Table 31. An example is illustrated below:

> *"When the project started we had frequent meetings regarding the nature of the business. They were only discussions with the head of Food Databanks and other colleagues to help shape what it would be, and also to put it in a position to get the translational funding in. Gradually it's got more and more independent and then we brought in Mike as business development manager" (I43P16, pg.2).*

This independence regarding decisions during the project can be observed in different aspects, from branding to forming a strategic alliance with another firm to develop the project further. These are illustrated in the following quotes:

> *"When we had to make decisions regarding the branding that was a big discussion because we needed to decide how independent we wanted to make NIS. We could have some many organisations linked to the brand, from IFR, BBSRC, Norwich Research Park, Food Databanks National Capability, IFR Extra. The problem is customers don't want to know about it, they just want to know what service we provide. But there are political policies, for example, IFR and BBSRC wanted to have their labels on the website. I had to make the branding decision myself on behalf of IFR" (I43P16, pg.2).*

> *"I went ahead and met them (Nutritics). I went alone. I have done strategic alliances before and in my opinion collaboration now is everything, allows you to scale much quicker" (I47P29, pg.4).*

Another important decision that took independent action was on how they would approach food producers, particularly SMEs, to make them aware of their service. They did this mainly through established networks which worked in two ways. The networks allowed them to reach SMEs via their contact lists. Also, SMEs were able to contact and use NIS services because they were part of a network. This decision to use their networks can be illustrated in the following quote:

> *"We hit some organisations in Norfolk of the food and drink network, and we've gone to them and say – can you please tell your members, we've got this service and we'll give you a discount. Seeing from their response, that's the best cost per acquisition." (I31P29, pg.2).*

During discussions and negotiations, there appears to be a great deal of trust involved, which made the communication effective, allowing the development manager to carry on proactively seeking to improve the project:

> *"We engage and we discuss a lot. The scientists trust my business experience and I trust their scientific knowledge. I presented strategically the issues that I saw with NIS that was only going to be for small businesses" (I47P29, pg.2).*

> *"I've made the decisions alone on how to go about meeting SMEs and doing all the marketing. It was very empowering because they felt confident I could do that, they believed I had the experience. We do work really well as a team because I need them, they need me" (I47P29, pg.3).*

One of the main outcomes from this autonomous way of making decisions was the opportunity to pitch to the UK Trading Standards and Environmental Health, which gave the opportunity to train their officers, consequently increasing the exposure of NIS and their services exponentially:

> *"In the UK Trading Standards and Environmental Health look after businesses, they are the ones that have to implement this new legislation. I went to their exhibition and told them about our services and they loved it. So now we are training their officers and hopefully make them aware of our services and they take out our services to others businesses" (I47P29, pg.2).*

There are some mechanisms that could be abstracted from this evidence, for example, *trust, negotiation* and *adaptive self-regulation*. A *trust* mechanism partly helps to explain an outcome, particularly the one related to hiring a business development manager. By trusting each other's decisions and capabilities, scientists and the business development manager were able to move the project forward in an effective way. The mechanism of *negotiation* could be explained by the interaction of actors, both in the early discussions and meetings on funding options for the project; and also later in the discussions regarding the strategic alliance. Nonetheless, from the evidence it is argued that a predominant transformational mechanism for NIS is *adaptive self-regulation*.

Adaptive self-regulation can be defined as when individuals "can respond to the complexity and dynamic pace of their immediate environment in a timely fashion" (Tsui and Ashford, 1994, pg.93). This concept is linked to the persistent pursuit of goals and the adaptive facet of effective self-regulation (Wrosch et al., 2003). In the NIS case, actors responded to critical processes such as the decision on branding NIS and the decision on creating the strategic alliance very quickly. This can be related to the fact that the legislation was fast approaching, therefore they needed to get the business from food producers as soon as possible. Also, they had to swiftly adapt their business model in order for NIS to survive and prosper once the legislation was in place.

One of the outcomes intended from these actions and interactions is that food producer SMEs use their services and consequentially obtain a sustainable business model. In order to achieve this outcome, actors involved in the project had to make autonomous and quick decisions, even though they were restricted within a social structure consisting of multiple constituencies or stakeholders (scientists, SMEs, IFR strategy board, business development manager, and so on).

This kind of mechanism tends to have a functionalist explanation, where the consequences of the actions for a certain situation have a purpose and will produce a beneficial effect. In this case, for example, an actor – the development manager - intentionally looked for alternatives to grow and sustain the project, deciding on a strategic alliance with a Software as Service (SAS) type of firm. This particular action was created with the purpose of future sustainability.

Table 31 offers a summary of some of the evidence collected during fieldwork, providing some quotes from the interviewees. They represent the link between evidence and the interaction level macro codes, which are the actions and interactions. This evidence helps to support the narrative explanation at the interaction level, consequently supporting the abstraction to the transformational mechanism.

Table 31: Finding the transformational mechanism for knowledge transfer in NIS

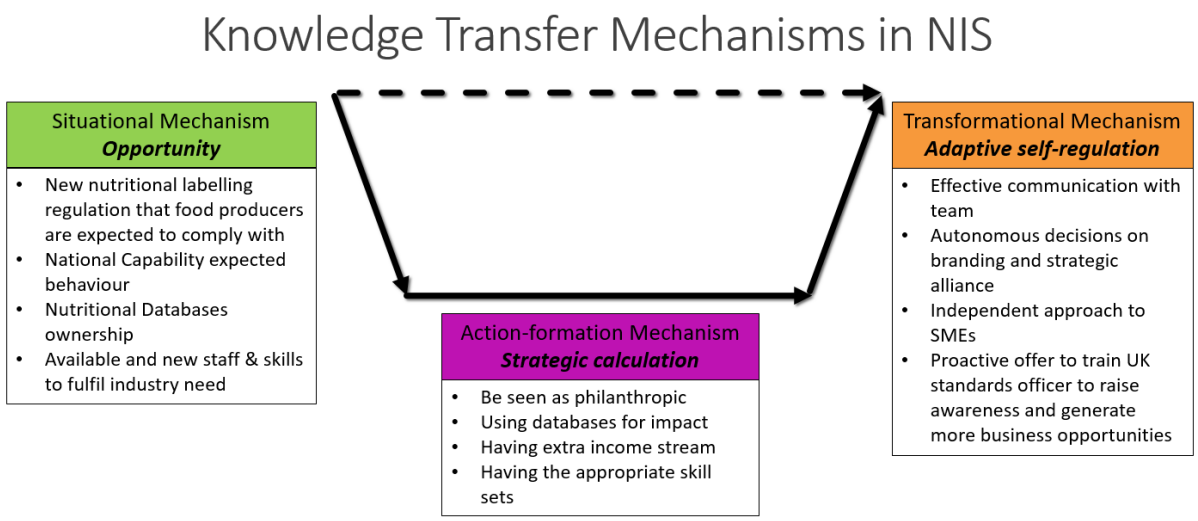
FINDING THE TRANSFORMATIONAL MECHANISM	
EVIDENCE – QUOTES AND SOURCES OF INFORMATION	**INTERACTION LEVEL MACRO CODES**
"We hit some organisations in Norfolk of the food and drink network, and we've gone to them and say – can you please tell your members, we've got this service and we'll give you a discount. Seeing from their response, that's the best cost per acquisition and we're going forward and hit the whole of East Anglia. To give you an idea, there are 1500 targeted business, 15000 products market" (I31P29, pg.2).	Actions (approach SMEs)
"When the project started we had frequent meetings regarding the nature of the business. They were only discussions with the head of Food Databanks and other colleagues to help shape what it would be, and also to put it in a position to get the translational funding in. Gradually it's got more and more independent and then we brought in Mike as business development manager" (I43P16, pg.2).	Interactions (meetings/discussions)
"When we had to make decisions regarding the branding that was a big discussion because we needed to decide how independent we wanted to make NIS. We could have some many organisations linked to the brand, from IFR, BBSRC, Norwich Research Park, Food Databanks National Capability, IFR Extra. The problem is customers don't want to know about it, they just want to know what service we provide. But there are political policies, for example, IFR and BBSRC wanted to have their labels on the website. I had to make the branding decision myself on behalf of IFR. NIS is the main thing, which is linked to Food Databanks, but do we need to even show that? Showing where is coming from can be quite important for some customers, others just don't give a monkey, they just want to know what you provide and what's going to cost. We're trying to pitch so there's no confusion." (I43P16, pg.2).	Actions (independent branding decision)
"When the NRP translation fund was running out, Mike had to develop the business plan which need further investment. We then looked at options on how to do that. We decided to take it to the IFR extra board. He made a persuasive case regarding the turnover and profit potentials and it got funded. So we put in an investment against future returns" (I43P16, pg.3).	Interactions (meetings, arguing)
	Interactions

"We engage and we discuss a lot. The scientists trust my business experience and I trust their scientific knowledge. I presented strategically the issues that I saw with NIS that was only going to be for small businesses" (I47P29, pg.2).	(discussion, presentation)
"I went ahead and met them (Nutritics). I went alone. I have done strategic alliances before and in my opinion collaboration now is everything, allows you to scale much quicker" (I47P29, pg.4).	Actions (decision to collaborate)
"I did the negotiations with them. Then I had to come back and sell the idea to Reg (IFR strategy board). That was tricky because it moved to quickly for them (IFR). Nutritics are very dynamic. IFR strategy board was a bit nervous, because they are quite risk averse" (I47P29, pg.5).	Action (negotiation and convincing board)
"I've made the decisions alone on how to go about meeting SMEs and doing all the marketing. It was very empowering because they felt confident I could do that, they believed I had the experience. We do work really well as a team because I need them, they need me" (I47P29, pg.3).	Action (decision on meeting SMEs)
"After a period of time, they realised that, although I'm autonomous, I communicate quite effectively with them. If I'm being honest, we probably should have kept them informed more than we did, because they were quite behind the pace" (I47P29, pg.5).	Interactions (effective communication)
"The scientist that do the calculations are funded separately from their salaries, so we negotiated with them on a zero hours contract. IFR extra does that with a lot of their staff anyway so it was a common thing to do. They love doing this work because it's their brainchild, and they were really pushing to make this happen" (I47P29, pg.3).	Actions (separate payment)
"In the UK Trading Standards and Environmental Health look after businesses, they are the ones that have to implement this new legislation. I went to their exhibition and told them about our services and they loved it. So now we are training their officers and hopefully make them aware of our services and they take out our services to others businesses" (I47P29, pg.2).	Interactions (training officers)

6.4.6 SUMMARY OF NIS

There are three predominant mechanisms affecting knowledge transfer at NIS: opportunity, strategic calculation and adaptive self-regulation, as illustrated in Figure 25. Food Databanks at IFR have taken advantage of a new nutritional labelling regulation to fulfil their National Capability duty on impact (opportunity). Driven by their motivation to work with SMEs and being seen as philanthropic, scientists and the businesses development manager exploited this opportunity by using their own datasets to provide a disruptive service (strategic calculation). A concern to maintain a sustainable business model going forward meant that decisions such as branding, creating a strategic alliance, contacting SMEs, training UK standards officers and so on, had to be made quickly and autonomously (adaptive self-regulation).

Figure 25: Knowledge transfer mechanisms in NIS



6.5 Conclusion

This chapter has introduced the predominant and less predominant situational, action-formation and transformational mechanisms for each project investigated. On each section, the project has been described, followed by a narrative explanation and quotes that explain each of the mechanisms abstracted through abductive reasoning. The predominant mechanisms at the BACCHUS project are *incentive, instrumental rationality* and *aggregation*, whilst at the SUSSLE project they are *reputation, self-interest* and *learning*. In the NIS project, the predominant mechanisms are *opportunity, strategic calculation* and *adaptive self-regulation*. The next chapter will offer a discussion into each mechanism and how they link to theoretical frameworks.

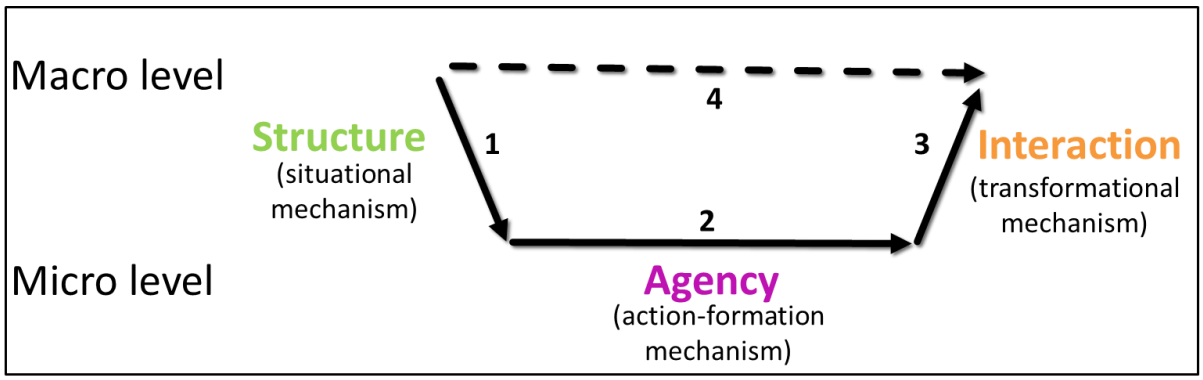
7 Discussion

7.1 Introduction

A central concern for this study has been to document and theorise, via an analytical process-tracing approach, the generative mechanisms of knowledge transfer in science-industry projects, to develop an explanation for how and why knowledge transfer happens. Because mechanisms are abstract concepts that are largely or totally imperceptible, they must be either conjectured, or as in the case of this research, inductively generated. Thus, there is a reliability on proxies to develop them, such as interviews, documentary records, observations and so on. It was important at the early stage of process-tracing, to think deeply about the conceptual mechanisms at play within these projects, and to be aware of feasible and justifiable proxies for assessing them.

The bathtub model (Coleman, 1994, Hedström and Swedberg, 1996) offers a way of organising a mechanism for the purpose of explaining a phenomenon, as illustrated in Figure 26. In the analytical model in Figure 26, (1) corresponds to the structure that impacts on actors, (2) corresponds to the actors choosing their actions and (3) corresponds to the interactions of actors that shape the outcome. In this study, the outcome is knowledge transferred from science to industry.

Figure 26: Analytical model



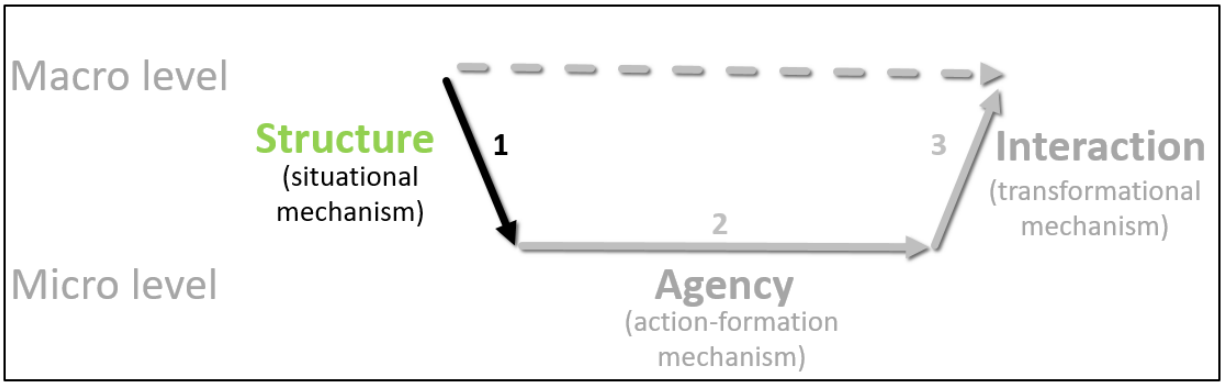
This chapter aims to discuss the generative mechanisms found within each project that was investigated and how it relates to previous literature. Although knowledge transfer has been on the research agenda for decades and there is a considerable body of literature and empirical studies, there are no studies that used a generative mechanism-based explanation. From a critical realist perspective, an investigation into the *real* ontological stratum is also a novel approach not only in this field, but also in management studies in general. The subsequent sections make a first step towards clarifying these aspects. Firstly, a short

summary of findings and a definition of the mechanism for the project is presented. Secondly, the findings that are linked to generative mechanisms are presented in relation to previous literature, starting from situational, into action-formation and then transformational mechanisms. These mechanisms might overlap and they are not necessarily exhaustive, as it is likely that there are additional mechanisms playing a role in knowledge transfer relationships that did not come to the fore in this study, due to the nature of its context. Lastly, an explanation is provided of how the mechanism is theoretically linked to the wider literature.

7.2 SITUATIONAL: THE MACRO TO MICRO LINK

This section will offer a discussion on the situational mechanisms abstracted from the projects, which is the macro to micro link in the analytical framework, as illustrated in Figure 27. These mechanisms offer insights into the interplay between social structure and human agency. In the analysis of the three projects, a range of generative mechanisms emerged which indicated the strength of structural conditions as well as their influence on the developments within the three projects. Margaret Archer (2003), in her theorisation about the relationship of structure and agency, states that the social structures act in either a constraining mode or in an enabling mode. These social structures come into connection with the individuals and it is up to the individuals to decide how to use and respond to those two modes. In other words, the causal power of structural factors to enable or to constrain are not inherent and may not be activated if they do not come into correspondence with the reflexive thinking of individuals and their potential reaction.

Figure 27: Situational Mechanism

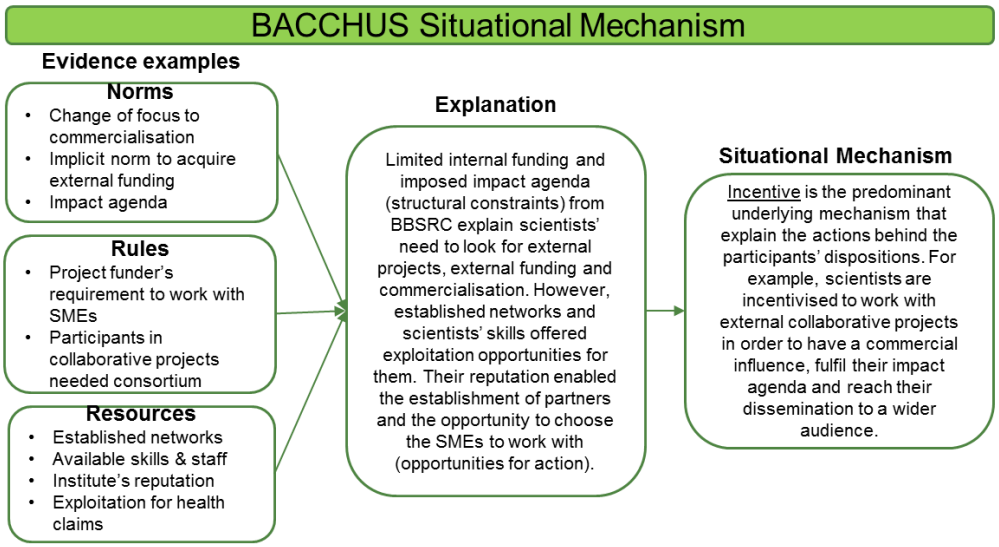


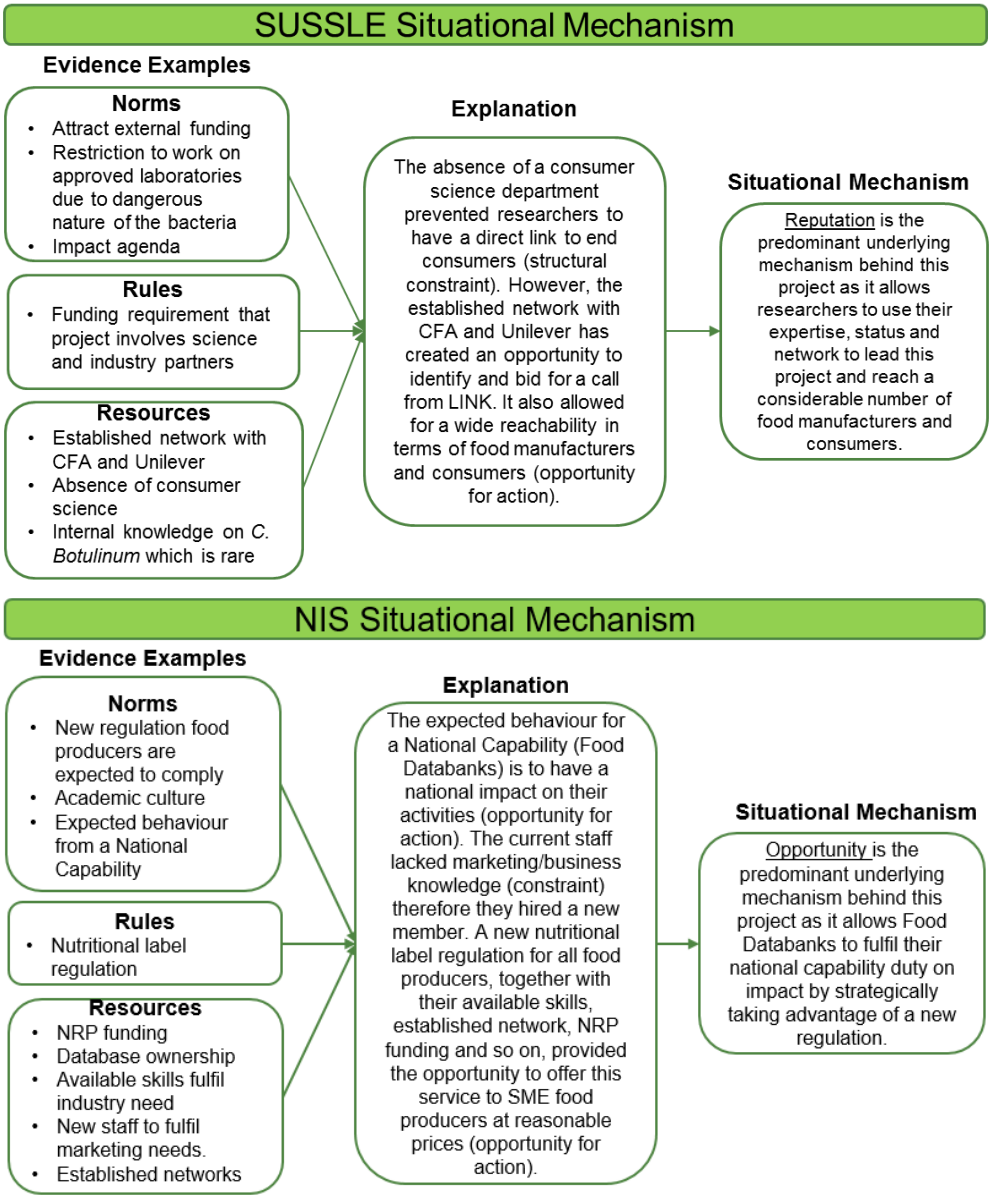
As discussed in the previous Methods and Findings chapters, the situational mechanisms are related to the structural side of the project, including norms, rules, and resources. These mechanisms link the macro to the micro level, and describe how these structures constrain or give opportunity for action and how they shape the beliefs and motivations of actors. Previous

studies in knowledge transfer have argued for variables but not generative mechanisms that relate to norms, rules and resources, and their structural constraint or opportunity for action. For example, Darr and Kurtzberg (2000) considered strategic similarity as a facilitator for knowledge transfer; Knockaert et al. (2011) looked at team composition in knowledge transfer relationships; Reagans and McEvily (2003) argued for the importance of network range; Large et al. (2000) identified the lead scientist as an important resource in science-industry knowledge transfer relationships; and Siegel et al. (2007) argued that technology transfer offices (TTOs) are key structural enablers for knowledge transfer opportunities. These studies explore the macro level influence on the micro level action, normally referred to as determinants for knowledge transfer. However, they do not look beyond these determinants into the generative mechanisms that brought them about.

This study has found that the predominant situational mechanism that drove knowledge transfer for the BACCHUS project was *incentive*, whilst for the SUSSLE project it was *reputation* and for the NIS project it was *opportunity,* as summarised in Figure 28. There are studies that make reference to these mechanisms however, as it will be argued in the next sections, the meaning is not always the same as this study's perspective. The next sections will look at the predominant mechanisms for each project, followed by a short discussion on the less predominant mechanisms identified.

Figure 28: Situational Mechanism at BACCHUS, SUSSLE and NIS





7.2.1 INCENTIVE: THE PREDOMINANT SITUATIONAL MECHANISM IN BACCHUS

BACCHUS was a large EU funded project that involved several partners, both scientific and industrial, and was led by IFR. The objective of the project was to develop scientific evidence to back up health claims for food and drink products to improve cardiovascular health. This evidence originates from the understanding of bioactive compounds present in fruits and vegetables and how they physiologically affect human health. The results from this project directly benefited the food manufacturer SMEs that were partners and, at a later stage, results were disseminated to other food manufacturers through guidelines, conferences and publications.

On the empirical level, the situational mechanism was manifested in several ways: the focus shift at IFR from research publications to the commercialisation of research, the need to look for external partners, and the strong position of the impact agenda which required wide dissemination of research findings. This shift promoted an unwritten norm of seeking external projects and external funding. The funding for the project, in this case, came with a pre-requirement to work with industrial partners, more specifically, food manufacturer SMEs. Due to IFR researchers' reputation and established networks, their ability to choose the other partners for the project was a positive outcome. These structural constraints, opportunities, and available resources, were driven by an *incentive* mechanism. Scientists were incentivised to work with external projects in order to have a commercial influence, fulfil their impact agenda and disseminate their research findings to a wider audience.

Incentive is an important mechanism for knowledge transfer that determines the actions on which scientists decide to work with industry. It also helps to demonstrate the connection between institutional norms and individual behaviour. As discussed in the Findings chapter, incentive can be described as "a reward or some form of positive feedback given when a desired behaviour is exhibited" (Dalkir, 2005, pg.309). In BACCHUS, it can be described as the driving force which leads to rewards for scientists working with external partners. It reflects how individuals approach implicitly imposed rules and norms. It also helps to explain the resources which scientists on the BACCHUS project utilised to put together the consortium panel for the project, from their established networks.

This incentive is similar to findings in other studies. For example, Knockaert et al. (2011) stressed the shifting context in the academic and scientific environments, highlighting the pressure faced by public research institutes to commercialise at least part of their research. This change has also been experienced within IFR, where a focus from publications has shifted to commercialisation. Current studies have tended not to try to understand why this is the case and how it affects scientific-industry knowledge transfer relationships.

Some studies (Lach and Schankerman, 2004, Markman et al., 2004, Link and Siegel, 2005) have argued that incentives are the main motivations for individuals to transfer knowledge and view knowledge transfer as a strategy to improve firms' performance. Although previous studies (Van Looy et al., 2011, Jensen and Thursby, 2001, Jensen et al., 2015) have shown a degree of correlation between incentives and knowledge transfer, which are consistent with theoretical predictions, the explanatory power of these studies is not very strong. To understand why this is the case, it is important to understand the generative mechanisms.

Incentive has been referred to in the knowledge transfer literature as a variable that positively associates with knowledge sharing. Ding et al. (2016) looked at positive economic incentives, and positive and negative relational incentives and how they affect employees' intentions to share knowledge and consequently impact the firm's performance. They concluded that economic and relational incentives exert influences on employees' knowledge-sharing activities. For example, economic incentives have been operationalised as salaries, bonuses, and promotions; positive relational incentives as respect, cooperation and perceived friendship with colleagues; and negative relational incentives as being frozen out by colleagues and repelled by supervisors. Similarly, Belenzon and Schankerman's (2009) study looked at pay incentives for university knowledge transfer activities, particularly at licencing, and argued that such incentives have a strong positive influence on licencing performance.

In these cases, incentive is viewed as a positive or negative motivational construct that can be measured, but not as a generative mechanism created by structural constraints and opportunities. One main difference between this study and others is the perspective of incentive, which consequently has practical management implications. For example, Ding et al. (2016) argue that for better knowledge transfer which then improves firms' performance, it is important that organisations have explicit and comprehensive incentive systems that include, for example, better pay and promotions. However, this study argues that incentive is a generative mechanism in a knowledge transfer case, which is institutionalised through implicit norms and situational changes such as the impact agenda. Therefore, whilst the project has been driven by an incentive mechanism, it does not necessarily mean that IFR's management should be offering financial incentives to scientists. What it means is that scientists behave in a norm-driven way, rooted in an incentive mechanism.

Contrary to previous studies, Lucas and Ogilvie (2006) and Colyvas et al. (2002) concluded that incentives have no influence on knowledge transfer. Lucas and Ogilvie (2006) argue that knowledge transfer is a social activity in which employees must willingly engage and which cannot be incentivised. The authors explain the lack of support between incentives and knowledge transfer as a lack of motivation, poor timing and types of incentives, and differences in expectations. Lack of motivation relates to how individuals perceive incentives as feel-good rewards rather than carefully designed tools to generate action. Timing and type of incentives relate to the rewards that are placed throughout different stages of the knowledge transfer process. If these incentives are poorly timed or lacking, individuals may become resentful and complacent, feeling that their efforts are not rewarded. Differences in expectations concern the degree of value that the sender and receiver place on the knowledge to be transferred, which

depends on the degree of uncertainty of the outcome. The greater the uncertainty, the lower the expectations and the less likely individuals are to engage in knowledge transfer.

This study disagrees with Lucas and Ogilvie (2006) with respect to uncertainty. Scientists at IFR were willing to work under uncertain conditions and the BACCHUS project did not offer much certainty regarding results. However, scientists were directly motivated by rewards in the sense that they had an expectation that the project would be successful and they would eventually reap rewards, such as publications and closer relationships with industry. Furthermore, this study builds upon current studies in the sense that incentive is identified as an important mechanism, albeit the view of incentive is different. Whilst most studies view incentives as tangible resources such as bonuses or promotions, this study shows that a system for tangible incentives is not necessary. This study reveals that the incentive is driven by explicit or implicit norms and individuals then take action from these norms. Hence, for BACCHUS, incentive is considered a norm-driven mechanism. From the empirical findings, incentive has been abstracted from an implicit norm which incentivised scientists to work with industry. Accordingly, incentive can be better explained by theory of compliance related to social norms.

Theorists have explored different approaches for explaining the complex factors and mechanisms that determine compliance. There are approaches that borrow insights from neo-institutionalist literature (North, 1990) whilst others developed complex models of individual rationality by borrowing concepts from psychology (Braithwaite and Braithwaite, 1994). Another approach to compliance theories comes from the perspective of social norms (Lessig, 1995) and this is the closest theoretical perspective to the incentive mechanism in this project. In this approach, social norms are understood in the sense of unwritten rules shared by a group, which are sanctioned, both positively and negatively, by the group's members.

A particular study by Gezelius (2002) poses pertinent aspects of social norms as determinants of compliance. He studied fishing communities in Norway and identified instrumental and strategic responses to social norms. Building upon compliance theory with a particular focus on social norms, Gezelius (2002) considers how and under what conditions different factors affect the choice to comply or not. Thus, he demonstrates the mechanisms by which individuals accommodate norms in small and relatively closed communities. One of the conditions is related to the strength of social networks among the fisherman, where social transparency is important and there is no clear distinction between work and leisure. The sense of community and belonging is strong and a fisherman's identity is linked to the membership of this collective. Through this ethnographic fieldwork, Gezelius (2002) argues that the reason fishermen follow

regulations is not to obey the law, but a moral obligation to avoid community gossip and social degradation. Thus, he concluded that the choice to comply or not with fishing laws was guided by an informally enforced set of social norms and not the laws themselves.

Following from Gezelius (2002), Jagers et al. (2012) concluded that, although the fishing industry is highly regulated with strict laws in Sweden, fisherman's compliance or non-compliance was determined by whether or not they feel morally compelled and whether or not compliance is believed to create a negative impression among peers. Social and moral motives therefore ranked higher than law abidance. Another study by Stern (2008) looked at trust as a predictor of compliance and as an important driver for collaboration, whilst Johnsen and Eliasen (2011) looked at cultural conditions' relationship to compliance.

The context of these studies relate to the context of IFR and BACCHUS, i.e. interdependence with collective resources, membership and networks to specific groups, strong links of acquaintanceship between recipients, and a strongly regulated industry. Thus, the analysis of the BACCHUS project offered a similar explanation, with incentive as a norm-driven mechanism that can be explained by a theory of compliance. For example, one implication of an incentive mechanism for this project is related to the interdependence of scientists and how they approach norms. Scientists at IFR work closely together when developing research proposals, as they share laboratories, facilities, and doctoral students. The membership to specialised networks also plays a vital role. The strong network ties (Granovetter, 1973) that scientists have among themselves and with other research institutes made possible the quick assembly of the BACCHUS project consortium.

In this case, rather than sanctioning a system of incentives such as financial rewards, bonuses and promotions, a focus should be on incentive conditions that encourage scientists to comply to knowledge transfer relationships with industry from a social norm angle. Thus, the issue of compliance sits at the management level of IFR and its wider environment, and not at the level of individual scientists. Therefore, it is a structural and not an individual matter. Financial incitements are not likely to work, whereas different instruments associated to social norms and the justification of rules are more likely to be beneficial. It can be argued that incentives validate a social norm that reinforces scientists' behaviour to transfer knowledge. Thus, it is important to emphasise efforts that nurture social relationships and interpersonal interactions before launching into industry-engagement activities. Fostering an incentive that gives value to sharing behaviours is likely to increase the mutual social exchange relationships that are apparently important in driving knowledge transfer intentions. It can also be argued that providing a work environment characterised by high levels of organisational citizenship would

support the formation of robust communities within IFR, consequently supporting the social norms of sharing.

7.2.2 REPUTATION: THE PREDOMINANT SITUATIONAL MECHANISM IN SUSSLE

The SUSSLE case was a smaller project, also led by IFR and externally funded, which involved fewer industrial partners, but with the potential to reach a larger number of SMEs due to one of the partners being the Chilled Food Association (CFA). CFA has members from most of the chilled food manufacturers in the UK, who have access through their membership to guidelines from collaborative research such as SUSSLE. The safety criteria for these manufacturers is very strict, with precise cooking conditions and controlled storage and use-by dates to prevent food spoilage and consequently food poisoning.

One of the main concerns in this subsector is *Clostridium botulinum*, a highly dangerous bacterium that few laboratories in the world have the facilities or expertise to study. Another pressure faced by chilled food manufacturers is related to food waste, so increasing the shelf-life of prepared foods, informed by a comprehensive understanding of *C. botulinum,* is a growing industry need. These circumstances offered the conditions for scientists at IFR to utilise their scarce expertise and established networks to fulfil an industry need. Thus, the aim of the SUSSLE project was to understand the levels of *C. botulinum* in raw food ingredients to help chilled food manufacturers to deliver safe foods with a longer shelf-live and consequently lead to less food waste.

The predominant situational mechanism abstracted in SUSSLE is *reputation*. Reputation as a mechanism for knowledge transfer highlights the importance of delivering results and maintaining good relationships with a wide range of actors such as businesses and organisations like CFA. As discussed in the Findings chapter, reputation is based on opinion, or how much respect or admiration someone or something receives, based on past behaviour or character (Klein, 1997). In this case, IFR's reputation comes from past performance and perceived know-how; rare expertise in dangerous bacteria; an international standing from research into these bacteria; specialised laboratory facilities and established networks with industrial partners.

The findings from this study build on previous research. Lucas and Ogilvie (2006) argue that reputation has a strong positive association with knowledge transfer. Coming from a perspective that knowledge transfer is important for the competitive advantage of firms, they look for factors that help to explain successful knowledge transfer. Reputation involves assumptions about the value of prior actions to future expectations. Lucas and Ogilvie (2006)

conclude that good reputation facilitates knowledge transfer by reducing the need for constant monitoring between sender-receiver, which in turn improves transparency and speed of information sharing.

Studies have also viewed reputation as a tool that organisations use to assess potential partners and reduce the inherent uncertainty within knowledge transfer relationships (Low and Robins, 2014, Dacin et al., 2007). This assessment shows that a high reputation of the source has a strong positive association with the value of the knowledge that is transferred, which has a greater effect on firms' performance.

This study agrees and builds on these arguments by identifying reputation as the main mechanism driving knowledge transfer at SUSSLE. IFR's expertise on the dangerous bacterium *C. botulinum* created a worldwide reputation for their research. Due to the nature of the bacteria, there are few laboratories that have the facilities to research these bacteria. The bacteria are incredibly important because they are present in raw food ingredients and have devastating health consequences for humans. The scarcity of specialist laboratories and scientists able to study these bacteria have put IFR in a prominent position and they have conducted significant research that has been widely adopted by industry to improve food safety. This specific case had a high impact for food manufacturers as it investigated the bacteria in different heat treatments which would increase products' shelf-life, ultimately reducing waste.

The findings are also in agreement with previous studies which argue that individuals with good reputations are more likely to engage in knowledge transfer with other similarly reputable individuals (Lucas and Ogilvie, 2006). The SUSSLE project was dependent on networks and relationships with other organisations which IFR had worked with in the past. Not only IFR's reputation, but also the other partners' reputations, were taken into consideration when assembling the SUSSLE project consortium.

Reputation as a mechanism for knowledge transfer reinforces the idea that the process is highly dependent on the relevance and quality of research that scientists develop at IFR. It also reflects the importance of trust in social interactions and the strong influence of the relationships that scientists establish within and outside IFR. How they manage these relationships and the reputation they cultivate over time is also paramount. These relationships are rooted in trust and are the base for the successful use of networks. It can be argued that reputation is a mechanism that emerged from the relationships and interactions with other

partners. Thus, reputation has a socially-embedded nature where trust and networks are important.

One of the implications for reputation as a mechanism for knowledge transfer is that it carries a visible perceived status. In fact, reputation is part of the class of intangible assets identified as social approval assets, because they derive their value from favorable collective perceptions. Related constructs for reputation such as status, image, identity, legitimacy, and brand have been part of the discourse for this project. Being seen as an expert in the field was important for scientists and that was achieved through a mechanism of reputation.

Having a high reputation was a strong enabler for IFR to win the bid and assemble a consortium involving other high reputation organisations. One of the implications is that the association with high reputation networks and organisations allows for more successful bids for external funding. In SUSSLE, as previously discussed in the Findings chapter, reputation is not valued intrinsically, but on instrumental grounds and forms a base of trust and cooperation. If an *a priori* trust relationship exists, collaboration in a new project is executed more easily, as reputation can be a good measure of future potential contribution to the project.

Theoretically, reputation can be explained using a trust theory lens. Trust theory is based primarily upon expectations of reciprocity or perceived utility in strategic interactions (Mollering, 2006, Hardin, 2002). This rational perspective on trust is commonly based on predictability and past performance with relation to the costs and benefits of the action under consideration. In this case, scientists' expertise is validated by reputation established over time. The development of trust requires enough information for the trustor to make an assessment of expected outcomes. As such, trust is primarily cognitively based, consisting of the perceptions of the ability and integrity of the trustee combined with consistent past performance. Generally speaking, the presence of trust enables knowledge sharing and knowledge transfer.

Recently, authors have referred to trust to explain reputation, particularly in the areas of computing studies (Raj and Babu, 2017, Chiregi and Navimipour, 2016, Ert et al., 2016) and supply chain management (Chang et al., 2014, Wagner et al., 2011, Suh and Houston, 2010). For example, Chiregi and Navimipour (2016) looked at how reputation in a cloud computing environment affects users' trust in using the service, whilst Raj and Babu (2017) study the level of trustworthiness for users in social network environments and how it varies depending on the reputation level of the users. These views align with the findings from SUSSLE, as reputation is directly linked to individual scientists and the trust in IFR as an organisation departs from these individuals.

Drawing from a collective action perspective, Tucker (2008) looked at how organisations manage their reputations through trade associations. By looking at various business sectors, he builds a model of reputation that drives the dynamic relationship between trade associations, firms and multiple stakeholder groups. Although Tucker's study is exploratory, the theoretical framework that he offers resonates with the general environment around SUSSLE. For example, the trade associations that businesses rely upon are similar to the network affiliations that IFR relies on to spread their reputation. This network view could help in understanding deeper levels of structures and how resources are connected to organisation's value-creating processes. Another interesting point is the dynamic relationship with multiple stakeholder groups. If we look at a macro level, pressures and scrutiny from BBSRC and government regulations mean that having a good reputation might ease IFR's relationships with industrial partners. At a network level, reputation acts as a lever to choose project partners and at an internal level can serve to enhance the retention of skilled and resourceful scientists. However, coordinating the various activities involves trust in IFR's partners and vice-versa. It is a challenging task that directly influences IFR's reputation and the reputation of its scientists.

7.2.3 OPPORTUNITY: THE PREDOMINANT SITUATIONAL MECHANISM IN NIS

NIS started as a small project led by IFR and was internally funded. The aim of the project is to provide nutritional label information to food manufacturer SMEs from their recipes rather than from laboratory compositional analysis. This is a much quicker and more cost-effective way of calculating nutrient content. The idea came from IFR scientists after a new EC Food Information Regulation became mandatory, which stated that all food producers must comply with the new legislation by specifying all nutrients on their packaging.

By drawing from their expertise and ownership of Food Databanks, which is the UK composition of foods datasets, scientists developed this service to attend to the demand of SMEs and to support their National Capability position. Food Databanks is a research unit within IFR and as a BBSRC-funded National Capability, it is intended to benefit the scientific community in general and requires pathways to impact such as the generation of applied research and commercialisation.

Within NIS, the situational mechanism was manifested in various ways: the new nutritional label regulation that food manufacturers are expected to comply with created an opportunity for scientists to tap into their resources and offer an affordable and fast service. Having the ownership of Food Databanks meant that scientists could build a web-based service that

industry could use almost immediately. The only capability that IFR lacked was a dedicated business development manager that could take this forward. Having successfully applied for internal funding, they were able to hire a dedicated manager with business and industry experience to take the project forward. Another important enabling element for this project was that both the existing scientists and the new development manager had established networks which made it possible to quickly promote this service. NIS fulfilled an important pathway to impact from a National Capability perspective, which was the successful commercialisation of its scientific research. By translating their knowledge of food databanks and compositional analysis into a tangible service to food manufacturers, IFR used this opportunity to achieve impact.

Therefore, the predominant situational mechanism at NIS can be defined as *opportunity*. As discussed in the Findings chapter, *opportunity* is the "conscious policy or practice of taking advantage of circumstances" (Barney and Hesterly, 2012). External regulation offered the opportunity to fulfil their National Capability duties regarding pathways to impact. By taking advantage of their datasets, using current scientists and hiring a business development manager, they were able to strategically use this opportunity to their advantage.

Opportunity has been typically referred to with a negative connotation in the general management literature (Coff, 2003, Barthélemy, 2008, Yam and Chan, 2015, Helper et al., 2000). For example, Bouncken (2015) study on alliances and open innovation in biotechnology firms, suggests that opportunity is a negative mechanism that can be limited if firms can employ specialised and complex knowledge, which hampers understanding by other firms because of its hidden character. Thus, an opportunistic behaviour among alliance partners could symbolise mistrust, diminishing openness. In the case of NIS, opportunity has a more neutral connotation, as scientists used their resources both to their own benefit regarding the pathway to impact, but also to attend to an industry need regarding compliance to the new regulation.

Conner and Prahalad (1996) contrasted an opportunistic-related perspective of the firm with a resource-based perspective. They argue that knowledge-based considerations outweigh opportunity. For example, they argue that individuals coordinate their productivity from knowledge-based resources rather than from just an economic, transaction cost perspective. Resources such as value and rarity can be valuable assets that also have the capability of generating competitive advantage. This alternative view aligns with the context of NIS. Rather than viewing opportunity from purely a transaction cost economics perspective, where individuals are guided by bounded-rationality, this project was dependent on the human capital represented by the scientists and the development manager, as well as the social capital

represented by their networks. It also taps into value as a resource. For example, the ownership of Food Databanks offered a valuable knowledge resource that was exclusive to scientists at IFR. This resource was used to create a service for food producers.

This study expands prior studies especially because opportunity as a mechanism within the knowledge transfer literature has generally been neglected. Prior studies have typically viewed opportunity from a transaction cost economics lens, rendering it difficult to understand other theoretical angles. This study is also distinctive since it addresses opportunity in a science-industry relationship inductively from primary data. This research design enabled the identification of this mechanism from a range of norms, rules and resources within IFR and its wider environment, examining the conditions that drove this mechanism to surface.

Opportunity is traditionally explained from a transaction cost economics and self-interest perspective, "with guile" as coined by Williamson (1975, pg. 255), where the lack of relational trust could lead individuals to break rules if they consider the utility of that violation exceeds the utility of being caught. Williamson (1985) later elaborated the concept of opportunity in terms of 'the incomplete or distorted disclosure of information, especially to calculated efforts to mislead, distort, disguise, obfuscate, or otherwise confuse' (Williamson, 1985, pg.47). His explanatory concentration on opportunity potentially ignores additional sources of organisational constraints and opportunities.

In contrast, opportunity in NIS was not purely related to self-interest, but also to compliance. Therefore, the conventional transaction cost interpretation of opportunity is taken with caution in this study. There are circumstances in which it is worthwhile to understand opportunity from a commitment and compliance angle. Therefore, for the NIS project, the opportunity mechanism is better explained from compliance theory. As previously discussed in section 7.2.1, there are different approaches to compliance theory. Unlike for the BACCHUS project, where an *incentive* mechanism was explained by compliance that originates from social norms, in NIS the *opportunity* mechanism can be explained from a utilitarian view of compliance.

Nielsen and Mathiesen's (2003) study on Danish fisheries presents an opportunistic approach to compliance on legislation. They argued that opportunistic behaviour influences compliance. However, opportunity does not equal violation or continuously breaking the regulations to obtain an economic gain. The high compliance in the Danish fisheries was primarily due to good legal financial opportunities, which consequently resulted in higher profitability for the fisherman. Similar to this example, it is argued that a compliance angle on the opportunity mechanism (Nielsen and Mathiesen, 2003) is more in line with this NIS case than a transaction

cost perspective (Williamson, 1975). This could be because (1) the outcome was fairly certain, i.e. there was a real need from industry which made the success of the project more likely; (2) there were already established networks that provided visibility to the service the project was offering; and (3) IFR's scientists have a fairly established reputation in food composition and analysis. Thus, the theory advanced here does not dispense with economic arguments, but rather adds another layer to it from a commitment and compliance point of view.

The implication for IFR is that scientists will ensure compliance to requirements for impact driven by an *opportunity* mechanism. Therefore, an instrumental approach to opportunity is an important tool to ensure support for scientists. Opportunity in this case does not necessarily arise only from self-interest, but also from the opportunity to support and work closely with industry. One of the ways to tap into this instrumentality could be to ensure compatibility between scientific research projects and industrial patterns of needs. This could mean a greater focus on input efforts rather than outputs. For example, instead of waiting for regulation to start a project, scientists could be given the opportunity to have these conversations with industry and to offer this kind of innovative service before regulations are even introduced.

7.2.4 LESS PREDOMINANT SITUATIONAL MECHANISMS

There were a few less predominant situational mechanisms in the projects as summarised in Table 32. These mechanisms are still important in understanding why knowledge transfer took place in these projects, even though they are not predominant.

Table 32: Situational Mechanisms

Project		BACCHUS	SUSSLE	NIS
Situational Mechanisms	Predominant	Incentive	Reputation	Opportunity
	Less Predominant	Persuasion Institutional Network	Scarcity Institutional Network	Institutional Network

Institutional and *network* are mechanisms present across all three projects, whereas *persuasion* and *scarcity* are only found in the BACCHUS and SUSSLE projects respectively. Institutional changes have affected all three projects and a number of common structural features could be identified. For example, the pathways to impact has affected all scientists at IFR in some way.

An *institutional* mechanism could be explained from an institutional theory framework (DiMaggio and Powell, 1983), which is premised on the notion that in highly institutional

environments, organisations' structures are shaped by responses to formal pressure from other organisations or by conformity to normative standards established by external institutions. An organisation like IFR is strongly shaped by BBSRC's agenda because it is IFR's core funder. Being a publicly-funded institute also affects the kind of research performed at IFR, which may therefore sometimes be more aligned with government policies than with industry needs.

Institutional theorists (DiMaggio and Powell, 1983, Dacin et al., 2002, Dorado, 2005, Meyer and Rowan, 1977) propose that organisational actions are driven by social justification, that is, by the desire of organisational actors to give a plausible and meaningful account of their actions. From this perspective, strategic activities are socially and normatively defined because their motives derive from an individual's propensity to legitimate or account rationally for such activities. In turn, firms are rewarded with enhanced legitimacy and reputation if they develop internal structures isomorphic with external institutional pressures. In all projects, scientists took this normative approach to selecting their partners, using their networks and matching requirements to their expertise. In BACCHUS, the institutional mechanism was made clear by the norms from the impact agenda to disseminate findings to a wider audience, whilst in NIS there was a strong pressure to hold the National Capability position. In SUSSLE, scientists could not reach consumers directly, which led them to work with food manufacturer SMEs instead to ultimately be able to offer safer products to consumers.

Network is also a mechanism present across all three projects. The social networks among IFR's scientists are characterised by Granovetter's term (1973) 'strong ties', in the sense that most of them socialise on a daily basis and share facilities and laboratories. The majority of partners in the projects have what Granovetter (1983) refers to as weak ties. The social transparency in these networks is potentially quite high, therefore a general sense of community tends to be strong. For BACCHUS, scientists' established networks were a main driver to form a consortium from centres across Europe, and to build a strong proposal. In SUSSLE, the *network* mechanism was reflected through the partners, particularly CFA, which was how SMEs found out about the project. In NIS, network worked in two ways: it was through the scientists' and the development manager's networks that they reached SMEs and it was through network associations that SMEs learned about NIS.

Persuasion is a mechanism present in BACCHUS but not as predominant in SUSSLE or NIS. It was abstracted in this project from its wider environment, mainly from the funder's requirements, the EC. In this case, scientists' research and the consortium were closely matched with the EC call, which offered a good chance of a successful bid. This match

persuaded scientists to bid for this call, even though there were alternative funders available. Another mechanism, namely *scarcity*, appears within SUSSLE, but less so in BACCHUS or NIS. The perceived quality of IFR's research on *C. botulinum*, and scarce expertise and laboratory facilities were drivers for the commitment of other partners and led to the smooth running of the project. The following section will look further into conclusions regarding situational mechanisms and explain why some mechanisms are more predominant within each project.

7.2.5 Further Conclusions

The importance of the social context helps to explain why individuals get involved in knowledge transfer. Mechanisms such as *incentive*, *reputation* and *opportunity* show that individuals engage in knowledge transfer if there are social norms in place, if they are sending or acquiring knowledge from similarly reputable partners, and are operating in a culture that encourages sharing. It can be argued that these mechanisms help develop a sense of ownership whereby scientists feel a personal affinity to the knowledge transfer process effort and are committed to its success.

An *incentive* mechanism from a social norm angle suggests that IFR is strongly shaped by the social interactions among scientists to comply to BBSRC's impact agenda, for example. It could be argued that incentive at BACCHUS was predominant because the autonomy to put the consortium together was important to scientists, allowing them to choose the SMEs they would partner with. Autonomy was not prevalent in SUSSLE, and they did not have to work directly with SMEs. Instead, they worked with CFA and Unilever, only presenting the findings to SMEs in workshops later on. NIS presents a similar case to SUSSLE where again, SMEs were not partners in the project, but they were disseminated to as part of the project.

The importance of *reputation* as a mechanism for knowledge transfer suggests that even one-time only projects have repercussions that go beyond the bounds of that exchange. Potential partners in future projects are likely to take cues on what behaviour and results to expect in exchange with others. By the same token, an *opportunity* mechanism was predominant in NIS but not in BACCHUS or SUSSLE, potentially because these projects did not have the extra responsibility of safeguarding a National Capability position.

Most of these mechanisms are likely to be present in knowledge transfer relationships, and particularly in science-industry contexts. In order to discover additional mechanisms, further interviews would be required. Other research institutes have similar contextual environments, particularly in the UK, which means these mechanisms are likely to be present within these

organisations. All of these research institutes depend on external funding to further their research, they are under the scrutiny of either research councils or similar funding bodies; and they belong to extensive networks and affiliations.

Another aspect that relates to all projects is the value of the scientists to the institute. Thus, scientists' retention seems to be vital in terms of their expertise which builds reputation for the institute. Building capabilities and resources for the institute's visibility can lead to the generation of extra funding, as was the case in these projects. The absence of these factors will likely create the conditions for knowledge transfer to be unsuccessful or less successful than anticipated.

According to Mahoney (2000), typical explanations in social sciences are normally classified as either: utilitarian, functional, power or legitimacy. These explanations sometimes have mechanisms that overlap, however, they offer very general examples of mechanisms. A surprising range of mechanisms that did not become evident in the fieldwork are related to the power structure and appropriation. Incentives, reputation and opportunity are more utilitarian or functionalist types of mechanisms, whilst coercion, culture or legitimacy would be closer to power and appropriation.

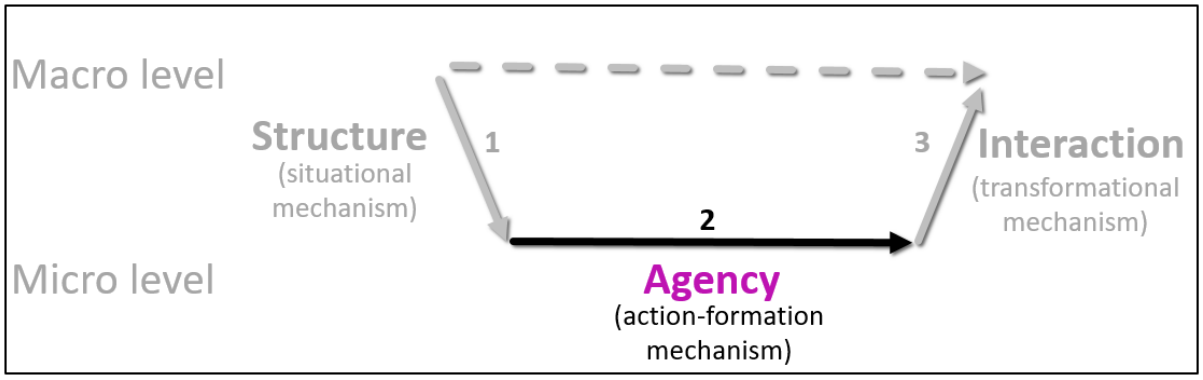
It could be argued that legitimacy types of mechanisms were not predominant because IFR and its scientists are well established in their industry, both in terms of time and also in terms of their reputation. However, the apparent lack of power related mechanisms is more difficult to explain. Because of the tightly controlled environment that IFR belongs to, it was expected that some power related mechanisms would surface. It is possible that to tap into power mechanisms, further data collection and interviews would be needed. Also, during fieldwork there was an open approach to interview questions, whereas mechanisms such as coercion would perhaps require deeper and more specific probing into IFR's structural constraints.

7.3 Action-formation: Beyond motivations and beliefs

Action-formation mechanisms represent the drivers behind the beliefs and motivations for individuals to take action. This section will offer a discussion on these mechanisms which is the micro to micro link in the analytical framework, as illustrated in Figure 29. As previously discussed in the Methods and Findings chapters, the action-formation mechanism seeks to explain the actor's behaviour and choice. For example, given the structural opportunities and constraints they are under, do they act in a rational-way, or in a value-seeking way, or in a meaning-seeking way, or by impulse? Do they strive to obtain closure, understanding, save

time or cognitive energy, or do they act to avoid negative emotions such as stress and frustration? Ultimately the action-formation mechanism looks for an explanation as to why people act given their motives and situations, ranging vastly between rational and logical to impulsive and visceral reasons. This mechanism is the level related to agency, which is the capacity of individuals to act and make choices, as well as the beliefs individuals hold. Motivation is often considered as either a physiological feature aroused in individuals that make them act in the direction of a specific goal, or as a rational thinking behaviour.

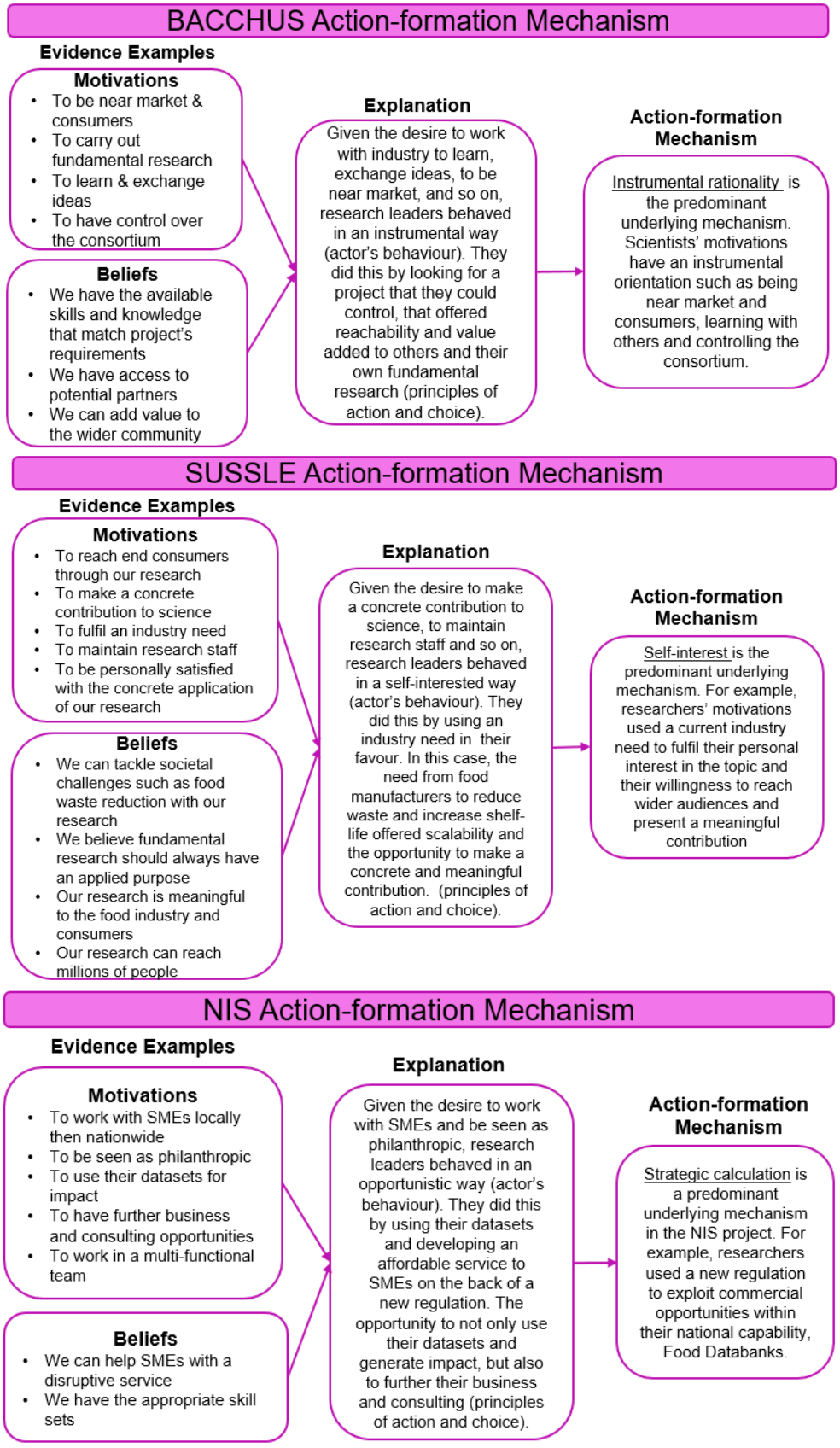
Figure 29: Action-formation mechanism



Beliefs are not transparent but should be taken seriously in the explanation of action. Even if these beliefs are biased or flawed, individuals tend to rely on those that work and that are subjectively deemed to be good enough (Simon, 1979). Although seemingly natural, looking solely at motivations and beliefs without further understanding the generative mechanisms that shaped those motivations and beliefs would not be considered a wholly mechanismic explanation. Furthermore, most previous studies in this discipline produce statements that tell us that two or more factors are related, which is a view aligned with positivism. Mechanisms will tell us why a phenomenon happened by looking into a deeper layer of reality, which is a view more aligned with critical realism and a stratified ontology.

In this study, the predominant action-formation mechanism that drove knowledge transfer for the BACCHUS project was *instrumental rationality*, whilst for the SUSSLE project it was *self-interest* and for the NIS project it was *strategic calculation* as summarised in Figure 30. There are studies that make reference to the motivations and beliefs that lead to these mechanisms however, as it will be argued in the next sections, there is a paucity of studies that look beyond motivations and beliefs. The next sections will look at the predominant mechanisms for each project, followed by a short discussion on the less predominant mechanisms and finally a conclusion.

Figure 30: Action-formation Mechanism at BACCHUS, SUSSLE and NIS



7.3.1 *INSTRUMENTAL RATIONALITY: THE PREDOMINANT ACTION-FORMATION MECHANISM IN BACCHUS*

As previously discussed in section 7.2.1, the BACCHUS project was driven by a situational mechanism of *incentive*, explained by the shifting focus of the impact agenda, the requirement of looking for external projects and funding, the available skills and networks, and the unwritten norm created by IFR's institutional environment. From this explanation of constraining and enabling structural conditions, it is important to understand how scientists respond, for example, did they respond in a rational or meaning-seeking way? Thus, on the empirical level, the action-formation mechanism was manifested through several motivations and beliefs: to be able to choose their partners in the project; to continue fundamental research; to be nearer to market; to access partners and technologies; to add value to the wider community; to have the available skills; and to learn and exchange ideas with partners. Thus, it is argued that scientists responded in a rational and instrumental way. Consequently, the predominant action-formation mechanism in BACCHUS has been defined as *instrumental rationality*.

As discussed in the Findings chapter, instrumental rationality is "determined by expectations as to the behaviour of objects in the environment and of other human beings; these expectations are used as conditions or means for the attainment of the actor's own pursued end" (Weber, 1978, pg. 24). In other words, it concerns practical reasoning that helps to decide how to do things, in this case, how to do more research, how to access technologies and how to achieve tangible results. Being a consequentialist mechanism and oriented towards the aforementioned outcomes, instrumental rationality shows how scientists used their resources to fulfil their desires. Thus, scientists looked for a project that they could control, that offered reachability and added value to their own fundamental research and ultimately others in the food industry.

Several studies have shown that knowledge transfer is motivated and executed at the individual level (D'Este and Perkmann, 2011, Göktepe-Hulten and Mahagaonkar, 2010, Lam, 2011b, Zaheer et al., 1998, Samieh and Wahba, 2007). For example, D'Este and Perkmann (2011) argue that most academics engage with industry with the aim to further their research rather than to commercialise their knowledge. This is congruent with these findings, particularly from the BACCHUS and SUSSLE projects. Lam (2011b) also argues that traditional scientists engage in knowledge transfer and the commercialisation of findings for reputational and intrinsic motivation, but also for extrinsic reasons such as "to obtain the much needed funding for research in an increasingly resource constrained environment." (Lam, 2011b, pg.1364). Owen-Smith and Powell (2001) suggest that working with industry is not necessarily

underpinned by entrepreneurial intentions, but tends to be more to respond to economic opportunities.

This study agrees, finding that scientists tend to be more motivated by non-pecuniary incentives. In the BACCHUS project, scientists wanted to carry out their research, but also to see it being applied in the market and with consumers. This finding is in line with what Lam (2011b) refers to as "pragmatic traditional" scientists. However, other studies are missing the generative mechanism behind these motivations. Being motivated to do further research does not explain why they do it, but only tells us that there is a strong relationship between scientists wanting to do further research and to transfer knowledge with industry or other partners. From a critical realist perspective, answering the why question means understanding the generative mechanism that gives rise to the phenomenon under study, reaching the third layer of reality where these mechanisms are situated.

This study also partly agrees with Göktepe-Hulten and Mahagaonkar (2010) on motivations related to reputation. They argue that researchers engage in knowledge transfer activities to signal their achievements and gain reputation amongst their academic and industry-related communities, rather than for personal profit. This study has found that rather than scientists being motivated to gain reputation, they used their reputation as a tool to gain access to projects and to be able to choose their project partners. However, this could be because most of the scientists at IFR were fairly well established, and therefore had already built their reputations.

Siegel et al. (2007) looked at entrepreneurial universities and the importance of understanding the individual motivational drivers for university-industry relations for organisational and societal implications. Similarly Bercovitz and Feldman (2008) find that faculty members' compliance with entrepreneurial behaviour can be substantial or symbolic, and only under certain conditions such as the presence of local entrepreneurial norms, do academics engage in substantial entrepreneurial behaviour as opposed to superficial compliance. These studies resonate with BACCHUS as its situational mechanism of incentive has been explained by a social-norm theory of compliance. On the other hand, how the scientists behave towards this compliance is much closer to their motivation to learn and do more research, as well as a belief that they can add value to society.

Although there are studies that reflect on motivations, there are few studies that address scientist's beliefs and opinions that are more closely related to individual's values that affect knowledge transfer relationships. Lam (2011b) has statistically tested scientist's value

orientation and the relationship with industry engagement. She categorised scientists into four groups: (1) 'pure traditional' believe academia and industry should be distinct; (2) 'pragmatic traditional' recognise the need to collaborate for pragmatic reasons; (3) 'hybrid' believe in the fundamental importance of science-industry collaboration for knowledge application; and (4) 'entrepreneurial' believe in the science-industry collaboration for knowledge exploitation. This kind of explanation taps superficially into the belief system of scientists, mostly indicating their motivations. According to this model, BACCHUS scientists would fall into the 'pragmatic traditional' and 'hybrid' types, as their belief was to utilise their skills and to apply their research for the benefit of consumers. Nevertheless, again existing studies do not attempt to understand the generative mechanism for these beliefs. In the case of this project, it is argued that this explanation was driven by an *instrumental rationality* mechanism.

Theoretically, *instrumental rationality* can be explained by several micro-theories of rationality. Weber (1978) was the first sociologist to distinguish two types of rationality that explain reasons for individuals to act and to believe. One type is instrumental rationality which represents acting efficiently to satisfy practical needs whereas the other type is value rationality which represents acting to conform to impersonal social rules. The Stanford Encyclopedia of Philosophy (Zalta, 2016) says that individuals display instrumentally rationality insofar as they adopt suitable means to their ends. In this case, scientists have pursued the project because they could choose and have control over the consortium, and they were believed to have the skills within their research group to achieve the goal of seeing their research in an applied form.

One theory that corroborates this context and helps to explain *instrumental rationality* as a mechanism is the theory of reasoned action (TRA). TRA assumes that human beings are usually rational and make systematic use of the information available to them (Fishbein and Ajzen, 1975). In this case, scientists used their capabilities and resources to fulfil their motivations and beliefs. According to TRA, an individual's behaviour is determined by their intention to perform that behaviour. Consequently, their intention is determined by their attitudes, subjective norms, and salient beliefs about the results or outcomes from their actions. Within the context of knowledge transfer for the BACCHUS project, scientists' belief that they could add value to the wider society was one aspect that determined their motivation to apply their research closer to the market and consumers.

Researchers have used TRA to explain different subjects, from technology adoption to knowledge sharing (Alajmi, 2012, Rehman et al., 2007, Bock et al., 2005, Ho et al., 2009, Samieh and Wahba, 2007). For example, Ho et al. (2009) used both the theory of reasoned action (TRA) and TRA with game theory (GT) to explain individuals' knowledge sharing

behaviour. Whilst TRA captures personal psychological factors such as attitudes and subjective norms, GT captures personal feelings and individual's decisions. They concluded that TRA presents higher accuracy than TRA combined with GT, mainly because individuals are not likely to analyse the decisions of others in a knowledge sharing relationship. Therefore, they concluded that knowledge sharing behaviour is determined by personal psychological factors (TRA) and not the decisions of others (GT).

Following from Ho et al. (2009), Bock et al.'s (2005) study on individual's knowledge sharing argues that when the behaviour being studied is strongly reflective of collective action, the subjective norms are likely to affect behavioural intentions directly. The view that TRA can explain an *instrumental rationality* mechanism in BACCHUS is in line with these previous studies. For example, scientists' strong intention to apply their research in practice together with high social norms to engage with industry were more important than the decision on how to go about it. Furthermore, scientists belong to a strong collective environment as was reflected by the *incentive* mechanism explained by social norms compliance. The implications for IFR mean that transparency and a focus on scientist's beliefs should take priority rather than their decision to engage with industry. An organisational environment conducive of social norms is likely to exert a strong influence on knowledge transfer relationships and further engagement with industrial partners. Thus, fostering facilitative work environments seem to be more effective than forced rules and mandates.

7.3.2 SELF-INTEREST: THE PREDOMINANT ACTION-FORMATION MECHANISM IN SUSSLE

As previously discussed in section 7.2.2, the SUSSLE project was driven by a situational mechanism of *reputation*, which was explained by their unique and scarce expertise in *C. Botulinum*, their established networks with CFA and Unilever, the absence of a consumer science department at IFR and the requirement to fulfil the impact agenda. From this explanation, the motivations and beliefs of scientists were expressed in several ways at the empirical level. They have a strong belief that research should have an applied purpose; they believe their research is meaningful for the food industry and they can reach many people through this project; they are motivated to reach end consumers; to make a concrete contribution, to tackle societal challenges, to maintain research staff and to fulfil an industry need. It is argued that scientists were motivated in a value-driven way. Consequently, the predominant action-formation mechanism was defined as *self-interest.*

As discussed in the Findings chapter, *self-interest* can be defined as "the pursuit of personal advantage, be it money, fame, power, reputation, salvation" (Elster, 2015, pg.68). The self-

interest mechanism is exposed by an intrinsic motivation, where the personal benefit arises from the satisfaction of the end product, in this case, to provide safer and less wasteful food products. The closer the scientists' personal interest to the topic, the stronger the connection to the project. In SUSSLE, scientists' desire to tackle societal challenges such as food waste was an enduring driving force for them to pursue this project. Furthermore, the existence of indirect reciprocity suggests that scientists behave in a self-interested way to further develop their reputation. It is likely that they also reciprocate in different situations to have opportunities for subsequent rewards.

This study is in agreement with previous literature in knowledge transfer. For example, Lee (2000) argues that academic researchers' most significant motivators for collaborating with industry are related to their basic research, which they want to sustain by securing funds for doctoral students and laboratory equipment. Haeussler and Colyvas (2011) also argue that keeping more team members is a strong predictor for scientists to get involved with industrial knowledge transfer and entrepreneurship. This view is consistent with SUSSLE, as a strong motivator for this project was to maintain their current research staff. Without SUSSLE, they would not have enough funds to keep their staff employed.

The personal satisfaction from the concrete application of their research was also a motivator in this case. This is in line with Göktepe-Hulten and Mahagaonkar (2010) who argue that scientists are motivated to engage with industry to apply their research. Similarly Lam's (2011b) argument that 'hybrid' scientists' personal interest in knowledge application appears to bolster a strong professional conviction to make their knowledge socially relevant. The social relevance proposed by Lam (2011b) is probably the strongest motivation for scientists to engage in this project and has roots in an interest to address such a major challenge as food waste.

Although previous studies have tackled scientists' motivations and beliefs to engage with industry, they have not investigated the mechanism driving these motivations and beliefs. For example, it is argued often in literature that scientists are motivated to work with industry to have a broader reach and to apply science. Even though studies argue that 'entrepreneurial' scientists are not solely motivated by commercialisation (Lam, 2011b), there is always an element associated with a scientist's values and their desire to work on something applicable and relevant to the wider industry and society. Thus, in SUSSLE, the self-interest mechanism driving their actions can be explained by theories that consider values and relevance.

Constant et al.'s (1994) theory of information sharing addressed the role of individuals' attitudes and norms towards information sharing including intangible information or expertise, which is part of people's identity. The theory showed that sharing intangible information depends on people's personal benefits. In this theory, self-interest reduces sharing while self-consistency increases sharing. Contrary to this view, in the case of SUSSLE, the mechanism of self-interest actually increased knowledge sharing. It was scientists' personal interest to be satisfied with the concrete application of their research that drove them to pursue this project with industry.

Drawing upon self-determination theory (Deci and Ryan, 2000, Ryan and Deci, 2000), *self-interest* can be defined as a value-driven mechanism in the SUSSLE project. According to self-determination theory, individuals are motivated to act when they believe their behaviours will lead to desired outcomes. Contrary to rational-choice and economic based theories, self-determination has roots in social psychological needs and motivations. Although it is a broad theory of motivation that includes agency and well-being, there are elements that help to explain the mechanism in this case. For example, it considers intrinsic motivations such as doing something for pleasure or satisfaction; extrinsic motivations such as doing something for rewards or outcomes; and amotivation which is having no intention to act due to not valuing the activity.

Niemiec and Ryan (2009) explained educational practice from self-determination theory. They suggest that both intrinsic motivation and autonomous types of extrinsic motivation are conducive to engagement and optimal learning in educational contexts. Additionally, they suggest that supporting students' basic psychological needs for autonomy, competence and relatedness facilitates their autonomous self-regulation for learning, academic performance and wellbeing. Following this view, a study by Yoon and Rolland (2012) looks at knowledge sharing in virtual communities through the self-determination theory lens. They suggest that perceived competence and perceived relatedness influence knowledge-sharing behaviours, however, perceived autonomy does not. They also argue that familiarity positively influences perceived competence and perceived relatedness.

The needs proposed in these studies – autonomy, competence and relatedness – were also visible within the SUSSLE project. For example, scientists showed an intrinsic motivation to tackle societal challenges and produce meaningful research, which represents the importance of relatedness. It can be argued that such behaviours are internally perceived, which means they are experienced as emanating from the self rather than from external sources, indicating autonomy. Scientists were also extrinsically motivated to maintain research staff and fulfil an

industry need. It can be argued that these were enacted to satisfy contingencies, such as the avoidance of ending up with a smaller research group or lacking the recognition of attending to an industry need, which indicates the need for competence. These examples are value-laden motives for the scientists to pursue SUSSLE.

The implications for IFR mean that strategies to enhance scientists' autonomy play an important part in their decisions to engage with industry. Thus, providing choices of projects with meaningful rationales for the application of their science could improve knowledge transfer. Another key aspect for autonomy is the minimisation of control. As discussed in the previous section on the situational mechanism for SUSSLE – reputation – it can be argued that an organisational environment that focuses on applied science could enhance the perceived relatedness need. Furthermore, strategies to enhance competence could involve subject familiarity and exposure to industrial communities.

7.3.3 STRATEGIC CALCULATION: THE PREDOMINANT ACTION-FORMATION MECHANISM IN NIS

As previously discussed in section 7.2.3, the NIS project was driven by a situational mechanism of *opportunity*, explained by the new regulation on nutritional food labelling, database ownership, easy access to internal funding and the requirements of a National Capability. From this explanation, the motivations and beliefs of scientists were expressed in several ways at the empirical level: they believe they could help food producer SMEs with a fast and cost-effective service; they had the available skills and resources, i.e. databases and development manager; they were motivated to gain further commercial opportunities beyond this project i.e. consulting; they wanted to be seen as philanthropic; and they were motivated to use their databases for commercialisation. It is argued that scientists acted in a strategic way by using this project as a tool to achieve their goals, consequently the predominant action-formation mechanism was defined as *strategic calculation*.

As discussed in the Findings chapter, *strategic calculation* relates to a general plan that is created to achieve a goal and is an approach that assumes a process characterised by exogenous, self-interested preferences and instrumentality (Schimmelfennig, 2005). In this case, scientists used a new regulation to exploit commercial opportunities within their National Capability, the Food Databanks. Having the ownership of the datasets and the skill sets to provide this service to food producer SMEs promoted a belief that they are offering a disruptive product. This belief was fuelled by their own motivation to help SMEs and for being seen as philanthropic, which is an exogenous way of being perceived. There is also an assumption that SMEs find compositional analysis prohibitively expensive, which could be true in some cases.

All these assumptions, beliefs and motivations have motivated the scientists and the business development manager to strategically position their business model and take action to create exposure, rapport and future business.

Contrary to BACCHUS and SUSSLE, scientists in this project were not motivated to further their research or maintain research staff. Instead, there was a strong focus on commercialisation and generating business opportunities. Lam (2011b) argues that scientists engage with industry for intrinsic reasons and that financial rewards play a relatively small part. The findings from NIS do not support this view as financial gains were the main motivation for the project.

Haeussler and Colyvas (2011) argue that scientists accrue rewards through the scientific, human, and social capital from which they can draw for their work. This study supports this argument. Scientists at NIS used their scientific capital, i.e. databases, to create a service to SMEs. They also draw from the human capital or the scientists that were able to analyse recipes' ingredients, and additionally by hiring a development manager. Social capital also played a key part in this project, as it was through the scientists' networks that NIS was made visible to SMEs. Thus, social ties with industry created a positive association with the commercial engagement.

There are some elements found in this study that seem to be scarce within the knowledge transfer literature. For example, scientists' motivation to be seen as philanthropic by their peers and their networks does not seem to appear in mainstream literatures. The belief that they were offering a disruptive service is also a scant motivation. What does this mean to this project? The findings parallel the economic research which generally views rationality as the driver for a strategic calculation mechanism.

Strategic calculation assumes that individuals are intentional actors. Theoretically, rational choice (Weber, 1978, Boudon, 1981, Boudon, 2003, Coleman, 1994), a branch of game theory, deals with the relations and actions socially committed among rational agents, offering a good explanation for the mechanism of strategic calculation. Game theory is a branch of applied mathematics used as a theory to explain the rational side of social science, including human as well as non-human players, such as, computers, animals, and plants. Being a micro-level theory, rational choice assumes that individuals are the basic agents of social phenomena and that their rationality is the causal mechanism that produces events in the social world. It assumes that individuals are purposive, goal-oriented, and intentional actors. Beyond this, however, rational choice theory does not directly identify the content of any individual interests

or choice options. In the NIS case, it can be argued that scientists' actions were intentionally geared toward the commercialisation of this service, with a clear goal of financial impact.

Contrary to SUSSLE and BACCHUS where scientists had more options in choosing their partners and even their funding, it is not clear that NIS had the same choices. That could be one of the reasons why they applied for an internal funding stream. Also contrary to the previous projects, which had a more deeply rooted sense of belonging, NIS appears to have more strategically rooted motivations. Although rational choice theory offers a good explanation for the mechanism of strategic calculation regarding scientists' motivations, it offers a weaker explanation regarding scientists' beliefs. A softer version of rational choice theory, such as Boudon's (1998) Cognitivist Model (CM), could explain this further. CM supposes that actions and beliefs are "meaningful to the actor in the sense that they are perceived as grounded on reasons" (Boudon, 1998, pg.191). It can be argued that scientists' belief that they were offering a disruptive service and consequently helping SMEs is rooted in the reasoning that they did market research to confirm that. It was also confirmed through their networks that small manufacturers would struggle to endure or afford compositional analysis. Their reasons for pursing this project do not need to be proved right or wrong, and it could be argued that the strength of their reasons is a function of IFR's context.

7.3.4 LESS PREDOMINANT ACTION-FORMATION MECHANISMS

There were a few less predominant action-formation mechanisms in the projects as summarised in Table 33. These mechanisms are still important to understand why knowledge transfer took place in these projects, but they do not appear to be the predominant mechanisms, and a further explanation is provided in the following section. They are defined as utility-seeking, collaboration, cooperation, altruism and rewards.

Table 33: Action-formation mechanisms

Project		BACCHUS	SUSSLE	NIS
Action-formation Mechanisms	Predominant	Instrumental rationality	Self-interest	Strategic calculation
	Less Predominant	Utility-seeking Self-interest Collaboration	Cooperation Rewards Altruism	Self-interest Rewards

Utility-seeking and *rewards* are mechanisms present in the projects. The utility-seeking mechanism present in BACCHUS has a direct link to scientists taking part in this project for financial and reputational gains, whilst rewards in SUSSLE and NIS had a link to fulfilling their

need to tackle societal challenges and fulfil a national capability agenda, respectively. Although these are important mechanisms, they were not chosen as the predominant ones for these cases because, as it is argued in the Findings chapter, it was a combination of motivations and beliefs that could be better explained by their predominant mechanism. For example, in SUSSLE a *reward* mechanism does not offer a sufficient explanation for scientists' motivations and beliefs, only reflecting scientists' need to tackle a societal challenge. *Self-interest*, on the other hand, offers a better explanation that takes into account not only their need to tackle a societal challenge but also their belief that research should have an applied purpose; their belief that this research was meaningful for the food industry and they could reach wider audiences; their motivation to reach end consumers; and to make a concrete contribution, to maintain research staff and to fulfil an industry need.

Other mechanisms present in SUSSLE were *cooperation* and *altruism*. Cooperation has a direct link to scientists' motivation to work with other partners. Because there was a clear industry need as well as a belief that scientists could help, they acted in a cooperative way when putting the consortium together. Another mechanism that is argued to be at play in SUSSLE is *altruism*. This mechanism is not easy to identify as a purely unselfish concern in helping industry or not. Rational-choice theory argues that even mechanisms like altruism can be reduced to self-interest motivations, such as a desire for reciprocity in the long-term.

Collaboration is another mechanism present in BACCHUS and to a certain extent has a similar connotation to *cooperation* in SUSSLE. In the BACCHUS case, *collaboration* is reflected by the motivation that scientists had to learn and exchange ideas with others which could have been driven partly by the willingness to cooperate with industry. *Collaboration* in BACCHUS represents working together with partners to exchange knowledge, whilst *cooperation* in SUSSLE represents working separately to achieve the goal of helping industry.

7.3.5 Further Conclusions

As regards micro theories and theoretical models of the agent, the data were clear that scientists at BACCHUS and NIS were most often instrumentally, rationally or strategically motivated. Contrary to this, SUSSLE scientists had more value laden motives and beliefs. Thus, personal utility and self-interest no doubt played their parts. An applied research orientation, motivation to get additional funding for laboratories and staff, and the motivation to use their skills for impact, are all related knowledge transfer activities in these projects.

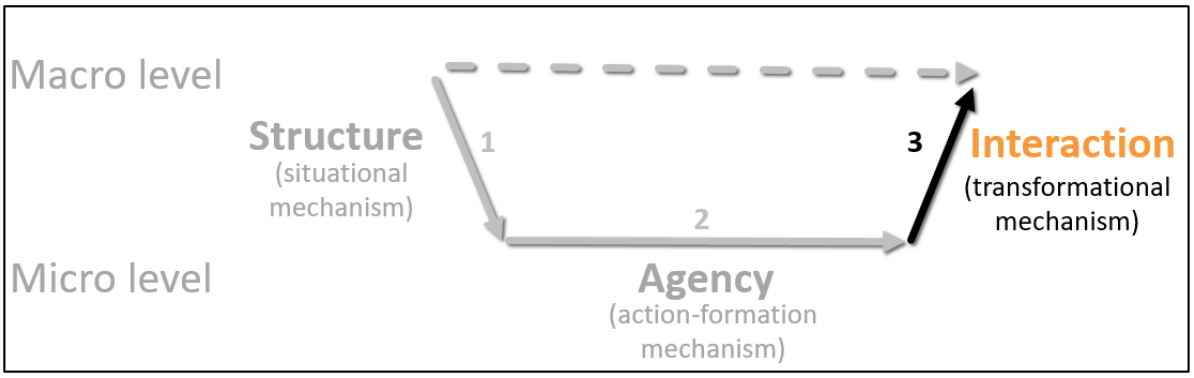
Surprisingly, there are some motivations and mechanisms that did not come forth strongly in the fieldwork. For example, there was not much evidence of elements like trust which Santoro

and Saparito (2006) and Zaheer et al. (1998) identified as the main driver for science-industry knowledge transfer relationships. Another element which was expected to surface is related to difficulties in translating findings, as identified by Liyanage et al. (2009) and Holden and Von Kortzfleisch (2004). Due to industry and science often having different understandings of knowledge, innovation and collaboration, translation barriers were expected but did not come forth in the evidence. Because scientists share laboratories and staff, it was expected that elements of peer pressure would be another common driver. For example, Tartari et al. (2014) argue that peer pressure influences academic scientists' industry engagement through the mechanism of social comparison. As previously discussed, social norms play a key part in these projects, but it did not come across strongly through the data analysis of the three projects in this study.

7.4 TRANSFORMATIONAL: THE MICRO TO MACRO LINK

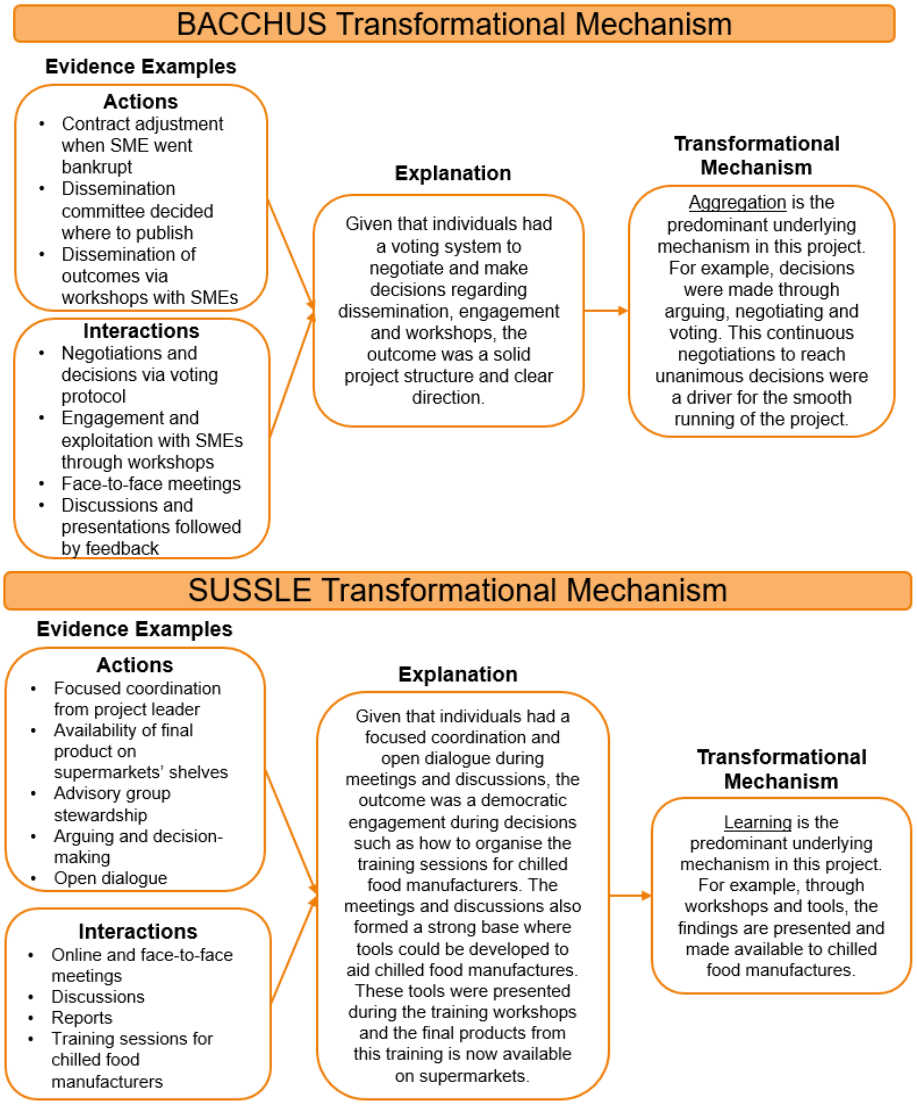
Whilst the situational mechanism helps to explain the macro-micro link, and the action-formation mechanism helps to explain the micro influences in the projects, it is the transformational mechanism that focuses on the actions and interactions that bring about an outcome. Therefore, this section will offer a discussion on these mechanisms which is the micro to macro link in the analytical framework, as illustrated in Figure 31. The micro-macro link was a major concern of James Coleman's (Coleman et al., 1957) work from his early research on innovation diffusion processes. Unlike many sociologists, he emphasised that macro-level phenomena must be explained by reference to the actions that brought them about. Thus, an explanatory theory should specify generative mechanisms that are likely to have brought about the phenomena, and this requires the demonstration of how macro states influence individual's actions (situational mechanism), and how these actions bring about new macro states (transformational mechanism).

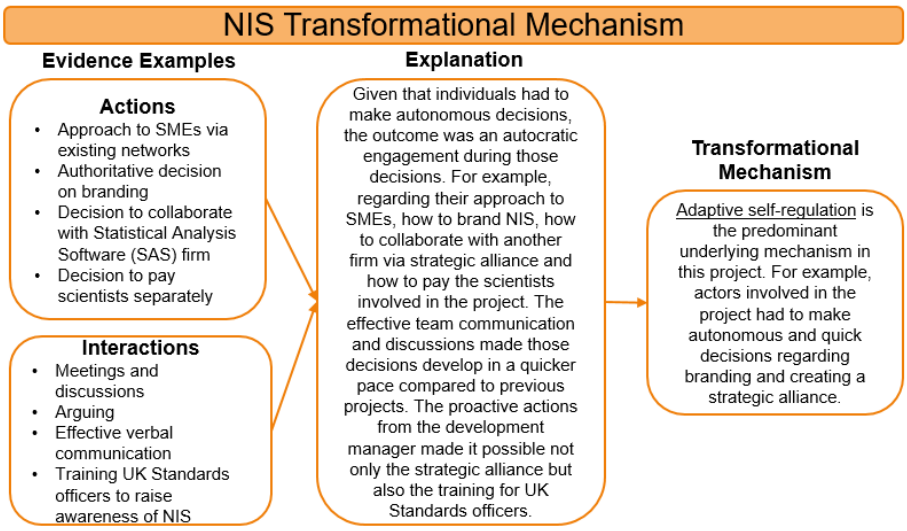
Figure 31: Transformational mechanism



This study has found that the predominant transformational mechanism that drove knowledge transfer for the BACCHUS project was *aggregation*, whilst for the SUSSLE project it was *learning* and for the NIS project it was *adaptive self-regulation*, as summarised in Figure 32. There is a paucity of studies that research the interactions of individuals and how they bring about an outcome. The next sections will look at the predominant mechanisms for each project, followed by a short discussion on the less predominant mechanisms and finally a conclusion.

Figure 32: Transformational mechanisms at BACCHUS, SUSSLE and NIS





7.4.1 AGGREGATION: THE PREDOMINANT TRANSFORMATIONAL MECHANISM IN BACCHUS

As discussed in the previous section, the BACCHUS project was driven by a situational mechanism of *incentive*, explained by a theory of compliance to social norms. From this explanation of constraining and enabling structural conditions, scientists responded in a rational and instrumental way driven by an action-formation mechanism of *instrumental rationality,* explained by a theory of reasoned action (TRA). From this point it is important to understand how scientists interact with one another and how these actions and interactions are transformed into the outcome of dissemination and knowledge transfer. Thus, on an empirical level, the transformational mechanism was manifested through several actions and interactions: negotiating via voting; engaging and exploiting SMEs through workshops, discussions and presentations followed by feedback; bargaining decisions to dissemination routes; and arguing decisions to adjust contract obligations. Accordingly, it is argued that scientists made decisions through a combination of arguing, bargaining and voting. Consequently, the predominant transformational mechanism in BACCHUS has been defined as *aggregation*.

As discussed in the Findings chapter, the *aggregation* mechanism denotes “any process in which actors who may have initially different preferences interact to bring about a decision that all of them accept as binding” (Elster, 2015, pg. 400). In the BACCHUS project, partners from various businesses and research centres have come together to make this project work. They all had different experiences of decision-making but had to agree on methods that would work for the majority. The project contractual agreement also offered further guidance on how to make decisions. Many examples given by the participants involved some level of arguing or voting, such as when a decision had to be made on the use of human studies or the decision to recruit a new SME because the previous one had gone bankrupt. IFR as the project

coordinator potentially had higher bargaining power over other partners, but bargaining alone was not the main channel for decisions.

There are some studies that look at decision-making and communication aspects in the knowledge transfer literature (Chung-Jen et al., 2014, Wu et al., 2016, Albayrak and Erensal, 2009, Böcher, 2016). For example, Chung-Jen et al. (2014) explored how cooperative competency, which includes trust, communication and coordination, has a mediating role between transfer mechanisms such as replication and adaptation, and how these affect knowledge transfer performance. There is a difference between this study and Chung-Jen et al. (2014) study in relation to mechanisms. The latter views mechanisms of replication and adaptation as the process by which firms receive knowledge. Replication is defined as "the extent of the recipients uses the transfer knowledge in their operations" (Chung-Jen et al., 2014, pg.2532) whilst adaptation is defined as "when the recipient modifies the transferred knowledge before using it" (pg.2532). Consequently, this view of mechanism is the process itself and how firms change their operations due to new knowledge. This study however views mechanisms as generative elements, considering instead which mechanisms lead to replication or adaptation.

On the other hand, there are similarities between this study and Chung-Jen et al. (2014) on the communication and coordination aspects, which are considered to be critical elements for successful knowledge transfer. Communication includes formal and informal sharing of information, and coordination refers to how activities, people, routines and assignments work together to achieve a goal. Chung-Jen et al. (2014) find that increased communication, through shared language and symbols, and more effective coordination to use the sender's knowledge in the recipient's context, help to increase knowledge transfer performance. This is partly in agreement with this study, where communication and coordination efforts played a key role in the success of BACCHUS. For instance, partners used meetings and interactions to understand each other's responsibilities, and giving and receiving feedback played an important role in moving the project forward, as illustrated in the following quote:

"By telling everybody what you've done, people can give feedback, question things, suggest ways to do it better. If you think, actually if you change that, question why you are doing it differently, even if it doesn't say in the contract…we can go back and change the contract" (I26P23, pg.12).

Another view of decision making in knowledge transfer that comes from a policy perspective in science-industry relationships is the research (R), integration (I), and utilisation (U) or RIU

model of scientific knowledge transfer (Böcher, 2016). In this model Böcher (2016) suggests how decisions are important regarding which scientific research holds appeal to policy and practice. This is what he calls the integration (I) measure in practice and how it leads to science-based policy advice that is relevant to policy making. This idea of relevance was a vital element within the BACCHUS project and the partners' adaptation to new processes of making decisions was driven by the relevance of the research for both academic institutes and industrial partners.

Albayrak and Erensal (2009) provide a methodology for identifying decision making problems for the transfer of knowledge by offering a linear programming model that includes both management and technological knowledge. One aspect of this method is the articulability of the knowledge and how it has an important impact on the ease of the transfer. This is similar to the integration measure within Böcher's (2016) model. Building upon this study, Liyanage et al. (2009) propose a comprehensive process model for knowledge transfer, which includes a conversion of knowledge in order to make it useful. This involves ensuring that the knowledge receiver has a knowledge-base heterogeneous enough to be able to take in new knowledge. In the case of BACCHUS, the heterogeneity of the receiving food manufacturer SMEs was a major concern for the partners. They had to make sure that the tools and training workshops they provided would be relevant to as many businesses as possible.

These studies focused on the process of knowledge transfer, but not the mechanisms that drive the process. Contrary to the previous studies, this research aims to analyse BACCHUS in depth to understand the underlying mechanisms that drove the actions and interactions of scientists. Therefore, this study builds on previous studies in the sense that if offers the narrative of the process but the real interest is in what lies deeper. For example, an aggregation mechanism in BACCHUS means that decision making should take account of a combination of techniques that are inclusive to all partners. If the project was exclusively managed by voting, there is a possibility that resentment could surface for some decisions, as the tendency is that the same partners are likely to vote similarly. The fact that they also decided through arguing and bargaining worked for most partners.

Theoretically, *aggregation* can be explained by decision theory with perspectives from organisational procedures (March, 1988) and to a certain extent from political views (Pfeffer, 1981). March (1988) contributed to decision theory with an organisational procedures perspective, which seeks to understand decisions as the output of standard operating procedures invoked by its subunits. This theoretical angle helps to explain aggregation in BACCHUS in various ways: the formal standard procedure offered by the funder, the EC,

provided specific guidelines for certain decisions and for the method of voting. This method worked up to a point, but further decisions arose in the project that were not covered by the funder's guidelines. Therefore, the partners, which included industry and science, had to come up with methods that would work for all. Being a fairly large group, meetings had to be tightly structured and bargaining succinct. It is possible to make a reference to the subunits mentioned by March (1988) for these various partners and their own experiences of decision-making. It is important to understand how decision-making processes work in order to influence them, for example, how the research reports were considered and evaluated. In this case, reports were sent electronically to all partners but the argumentation was held verbally, followed by feedback and formal decision.

The political view on decision-making (Pfeffer, 1981) sees it as a personalised bargaining process, driven by the agendas of participants rather than by rational processes. Individuals' differ on goals, values and the relevance of information. This political view can partly explain *aggregation* in BACCHUS, particularly when it refers to bargaining. The decision making context at BACCHUS was one of the main contributors to the project's success. It can be argued that one of the reasons for this was that the partners adopted various methods to negotiate and adapted to each other's value systems. Another aspect that facilitated decision-making was that partners seem to have kept the SMEs frame of reference throughout the project, which provided a common focus. It can be argued, therefore, that when facilitating decision-making in knowledge transfer relationships, the context and the customers' frame of mind should be kept as main priorities.

Encouraging participation and being sensitive to different value systems are also important implications for this kind of relationship. Approaches such as listening and responding, even if there is great uncertainty, seem to have worked in BACCHUS, as in the case of verbally arguing reports in the presentations of results. However, communication is a two-way process and persuasion skills should also be taken into consideration. Furthermore, issues such as the appropriate use of sensitivity to the political context are often overlooked. The results of this study seem to indicate that rather than following the normative approach that improves the rationality of individuals' decision-making, there might be merit in the support of an approach that is descriptive, focusing on the cognitive process and assuming that people are competent decision-makers.

7.4.2 LEARNING: THE PREDOMINANT TRANSFORMATIONAL MECHANISM IN SUSSLE

As discussed in the previous section, the SUSSLE project was driven by a situational mechanism of *reputation*, explained by a theory of trust. From the explanation of constraining and enabling structural conditions, scientists responded in a value laden way, driven by an action-formation mechanism of *self-interest,* explained by self-determination theory. From this point it is important to understand how scientists interact with one another and how these actions and interactions are transformed into the outcome of transferring knowledge. Thus, on the empirical level, the transformational mechanism was manifested through several actions and interactions: open dialogues, meetings, reports, training sessions to SMEs, focused coordination from the project leader and stewardship from the advisory group. Given that partners had a focused coordination and open dialogue during meetings and discussions, the outcome was a democratic engagement during decisions, such as how to organise the training sessions for chilled food manufacturers, and discussions about which tools could be developed to aid chilled food manufactures. Accordingly, it is argued that scientists' decisions were driven by learning outcomes. Consequently, the predominant transformational mechanism in SUSSLE has been defined as *learning*.

As discussed in the Findings chapter, *learning* is a process where individuals absorb something new such as knowledge, a skill, behaviour or value that they did not know before (Gross, 2015). In SUSSLE, a *learning* mechanism was rooted in two ways: (1) project partners learned from each other during meetings and discussions, and (2) food manufacturer SMEs learned from tools and guidance provided by IFR during the training workshops. The outcome intended during these actions and interactions is to translate the findings of the project into a digestible and useful tool for food manufacturers. Although the interaction of actors within SUSSLE is done through discussions and arguing, the underlying mechanism that translates those decisions into practice are rooted in a *learning* mechanism during the training workshops. Through a *learning* mechanism, the results from the project are absorbed by food manufacturers in the workshops and training sessions where there is an interaction with research leaders from IFR. From applying these novel processing methods, food manufactures were able to produce safer and less wasteful products, which are now on supermarket shelves. It can also be argued that partners learned from each other during the project. Although partners had a similar final goal, they came from different industries – food manufacturing, academia and science – and had different ways of working, which meant they had to adapt and learn new ways of making collective decisions within the SUSSLE project.

There are some studies that research learning in the knowledge transfer literature, however the meaning of learning is sometimes different from this study, or their methodologies reflect a different philosophical position (Li, 2012, Reagans and McEvily, 2003, Uzzi and Lancaster, 2003, Argote et al., 2000, Muthusamy and White, 2005, Braun and Benninghoff, 2003, Chen, 2009). For example, Li (2012) argues that learning capability serves as a moderating variable to suppress the negative influences of knowledge stickiness, therefore, it is considered an important strategic capability in terms of creating and diffusing knowledge to add value to organisations. This positivist view of learning sees it as a variable that organisations should carefully evaluate, but it does not offer any explanation, as it only provides a statement of a relationship between learning and smoother transference of tacit knowledge.

Reagans and McEvily (2003) hypothesised and confirmed the positive relationship between knowledge transferred and associative learning, which reflects that individuals find it easier to absorb new ideas in areas in which they have some expertise and find it more difficult to absorb new ideas outside of their immediate area of expertise. Similarly, Bercovitz and Feldman (2008) argue that academics' decision to disclose their findings appears to be influenced by peer effect, where learning activity occurs within a cohort of peers with similar characteristics. This view supports the findings from this research, and even though there were partners from industry, academia and science, they all had a goal in common and shared an expertise in the subject matter.

Following from Reagans and McEvily (2003), Uzzi and Lancaster (2003) study indicates that knowledge can be characterised according to whether it is public versus private and that the learning and transfer processes associated with each type of knowledge differs. For example, public information about an organisation provides a measuring tool for creditworthiness, however this must be confirmed by private information. Therefore, this interdependence between private and public would affect decision-making in knowledge transfer processes, as it affects the perceived credibility of the organisation. This was not the case for SUSSLE and the credibility of IFR or other partners did not emerge in this study. It could be argued that this is because IFR scientists knew most of the partners and trusted their networks would be just as credible, which is where the remaining partners came from. Thus, credibility was already established before the project started.

Levine et al. (2000) examine how group members develop a shared reality through their interaction with one another and how that shared reality shapes their problem-solving strategies. This view reflects some of the examples from this study, such as the interactions among partners during meetings and discussions and how, during the project, these

interactions created a sense of group identity which promoted knowledge sharing and the ability to give and receive feedback freely. Following this aspect of interactions, Muthusamy and White (2005) argue that social interactions and exchanges between partners are imperative for knowledge transfer success, which facilitates organisational learning. They also argue that the greater the reciprocal commitment, the greater the degree of learning accomplished. The aspect of social interactions came across in this study. It can be argued that because partners were from different countries, they perhaps did not have many opportunities to interact socially, although they did meet fairly often. Because they met in a country or place of business other than their own, it could be argued that this foreign environment would make social interactions even closer. Moreover, what came across was the sense of belonging to a team, which in turn facilitated discussions and learning among each other.

A different view on learning is offered by Braun and Benninghoff (2003). They look at rationality in the learning processes of research policies. They concluded that learning processes are a mix of rational and non-rational elements and that all learning processes may have a combination of interest and power. Although this study supports the claim regarding interest, it does not support the claim regarding power, as this was not evident in the findings. It could be argued that power did not come across strongly because this was a project environment where partners saw each other more equally, whilst for Braun and Benninghoff (2003) study, the context was learning in a policy environment where conflict and power are more visible.

Similar to previous studies, this study agrees that learning is a vital element in knowledge transfer relationships and that many aspects affect learning such as social interactions, shared goals, similarities and interests. However, unlike most previous studies that view learning as a variable that improves knowledge transfer and consequently organisational performance, this study views learning as a mechanism that drove knowledge transfer during interactions of individuals in SUSSLE and that facilitated the transference of techniques to SMEs. For example, a *learning* mechanism in SUSSLE meant that partners interactions were positive and sympathetic towards the goal of helping SMEs. This in turn, facilitated decision making and the creation of robust and useful tools for the food manufacturer SMEs, which are now fully available and in use by industry.

Theoretically, a *learning* mechanism can be explained by community of practice (CoP) theory (Lave and Wenger, 1991, Wenger, 1998). CoP takes into account individuals' common interest in a particular domain, and CoPs are usually created deliberately with the goal of gaining knowledge related to a specific field. Although CoP is not defined precisely (Lave and Wenger,

1991, pg.41), it is not a “primordial culture sharing entity” (pg.98); instead those involved have different interests and viewpoints; it is not a subculture. The use of the term ‘community’ refers to the “participation in an activity system about which participants share understandings concerning what they are doing and what that means for their lives and for their communities” (pg.98). This description of CoP helps to explain the *learning* mechanism in SUSSLE in three key ways: (1) partners in the project came from various viewpoints and experiences, (2) through a process of sharing information and experiences they had the opportunity to develop their own knowledge; and (3) because of this in-depth understanding of each other they were able to offer food manufacturer SMEs a more suitable processing tool.

One of the indicators of CoP theory suggested by Wenger (1998) is “the ability to assess the appropriateness of actions and products” (pg.125). This is a close explanation to what happened in SUSSLE. It can be argued that exchanging information among partners improved their learning process which in turn promoted a better engagement with the needs of industry. By creating specific tools and a shared discourse, the knowledge was translated in a practical and useful way, where SMEs were able to make use of the tools immediately. Therefore, learning is as much about understanding what to do, and to some extent is an identity change for partners to find a common meaning.

This is a useful theoretical perspective to explain the *learning* mechanism in SUSSLE because it is driven by task and focuses on achieving authentic, motivated learning about the complexities of real practice. Such interaction is a central proposition that learning is more than simply acquiring knowledge, it is about engagement and identity change. Therefore, the implications of this explanation for IFR can be seen in different ways. For example, it is possible to view SUSSLE as a community within IFR which means a greater attention to social relations can be channelled into organisational purposes. Given the right facilitation and dedicated time, such common ground can be the basis for forming dynamic groups based on direct social relations. However, it is essential to keep in mind that there might be some ambiguity as to whether or not this is genuine empowerment or simply the management introducing some form of normative control. Although SUSSLE was not a CoP, the interactions among partners could be described from a CoP perspective and this alone gives strong evidence that participation, engagement and active involvement were identified as key processes that were driven by learning.

7.4.3 ADAPTIVE SELF-REGULATION: THE PREDOMINANT TRANSFORMATIONAL MECHANISM IN NIS

As discussed in the previous section, the NIS project was driven by a situational mechanism of *opportunity*, explained by a utilitarian theory of compliance. From the explanation of constraining and enabling structural conditions, scientists responded in a strategic way driven by an action-formation mechanism of *strategic calculation,* explained by rational choice theory. From this point it is important to understand how scientists interact with one another and how these actions and interactions are transformed into the outcome of transferring knowledge. Thus, at an empirical level, the transformational mechanism was manifested through several actions and interactions such as: effective verbal communication; approach to SMEs via networks; autonomous decisions on branding; authoritative decisions to collaborate with a Statistical Analysis Software (SAS) firm; decisions to pay scientists separately; and training UK Standards officers to raise awareness of NIS. Given that individuals' interactions were highly autonomous, with well-defined skills and parameters to make decisions, the outcome was an autocratic engagement during those decisions. The effective team communication and discussions made those decisions quicker compared to previous projects, as they were driven by autonomous decisions. Consequently, the predominant transformational mechanism in NIS has been defined as *adaptive self-regulation*.

As previously discussed in the Findings chapter, *adaptive self-regulation* can be defined as when individuals "can respond to the complexity and dynamic pace of their immediate environment in a timely fashion" (Tsui and Ashford, 1994, pg.93). In the NIS case, actors responded to critical processes such as the decision on branding NIS and the decision on creating the strategic alliance very quickly. This could be explained in that the legislation was fast approaching, therefore they needed to get the service to food producers in a timely manner. Also, they had to swiftly adapt their business model in order for NIS to become sustainable once the legislation was in place. Thus, it can be argued that NIS decisions were driven by an adaptive self-regulation mechanism, as individuals involved in the project had to make autonomous and quick decisions, even though they were restricted within a social structure consisting of multiple constituencies or stakeholders.

This kind of mechanism tends to have a functionalist explanation, where the consequences of the actions for a certain situation have a purpose and will produce a beneficial effect. In this case, for example, an actor – the development manager - intentionally looked for alternatives to grow and sustain the project, deciding on a strategic alliance with a Statistical Analysis Software (SAS) firm. This particular action was created with the purpose of future financial sustainability.

There are not many studies that look at *adaptive self-regulation* in the knowledge transfer literature, however there are studies that look into elements from the narrative that led to this mechanism such as autonomy, teamwork, empowerment and so on (Tu et al., 2009, Molina and Llorens-Montes, 2006, Llopis and Foss, 2016, Ozlati, 2015). For example, Molina and Llorens-Montes (2006) look at how teamwork and an increase in individuals' autonomy affect knowledge transfer. They concluded that teamwork improves knowledge transfer, however greater autonomy only increases knowledge transfer when there are difficulties such as high tacitness. The findings from NIS support this view of autonomy, teamwork and tacit knowledge. For example, the project members worked as a self-directing team and the roles of scientists, the business manager, and SMEs were well-defined. The tacitness of the service they provided to SMEs, although it was straightforward to scientists, was something that SMEs could not have calculated by themselves, with the alternative being to have their food products analysed in laboratories rather than via recipes.

Following a similar context around autonomy and knowledge transfer, Llopis and Foss (2016) tested a model of intrinsic motivation and autonomy as moderators of knowledge transfer relationships. They suggest that an environment that emphasises efforts towards groups, rather than individual outcomes, is better for knowledge sharing when individuals show low levels of intrinsic motivation, but high levels of autonomy. This view is also shared by Ozlati (2015), who suggests that organisations can increase knowledge sharing by encouraging individuals' autonomy. Although this study supports the view on autonomy, it does not entirely support the findings related to intrinsic motivations. As discussed in the previous section 7.2.3, scientists in NIS were predominantly extrinsically motivated to undertake this project in order to further business opportunities and use their databases for impact. However, there was a motivation to be seen as philanthropic, which can be argued to be intrinsically rooted.

Another element that relates to individuals' interactions in NIS is their ability to organise themselves independently. Studies such as Jobidon et al. (2017) refer to the relevance of self-organising teams and role variability. They argue that high variability of individual's roles within teams is associated with poorer performance and coordination. They concluded that individual's role flexibility can be beneficial, however high role variability can cause ambiguity and consequently negatively affects goals achievement. This view aligns well with the findings in NIS. For example, individuals had well-defined roles and they also had a lot of flexibility to make decisions independently and to interact freely with each other. Consequently, the variability of roles was low, which could be argued to provide an effective way for the team to work together.

Another study that offers insights into how self-managing teams operate is by Tu et al. (2009). Their study explores the process through which a team dismantles its existing order and rebuilds a new one via innovations and changes which are spontaneously initiated by team members. They argue that clarification and identification of feedback structures are critical to the activation and success of a self-organisation process. This study is congruent with the findings from NIS. It can be argued that when NIS members came together they had to find a new way of executing their roles to deliver well-defined tasks and to identify and deliver new tasks. For example, scientists had built the databases and used them previously for consultancy, but for NIS they had to develop specific software to extract the kind of information they needed to match the new service they were offering to SMEs. Another element congruent with this study is in relation to feedback structures. It could be argued that one of the reasons the team worked well independently is because they had an effective feedback loop during the few meetings and discussions.

Although these studies offer detailed processes for self-organising teams and for the impact of autonomy and the relevance of teamwork in knowledge transfer relationships, they do not offer explanations based on generative mechanisms. From the explanation of individuals' interactions within NIS, an *adaptive self-regulation* mechanism can be explained by empowerment theory (Stewart, 1994). Empowerment theory often refers to processes of giving individuals greater discretion and resources, to increase their degree of autonomy and self-determination to act on their own authority. This distribution of power helps individuals to take control of their circumstances and achieve goals.

This theoretical angle helps to explain *adaptive self-regulation* in NIS in various ways: (1) all project members had a high degree of discretion regarding resources and decision-making; (2) the business development manager had authority to make decisions independently, even though they needed approval from the project's board; and (3) there was a strong culture of trust and NIS members were confident with their responsibilities. It can be argued that an appropriate structure and information and communication system was in place. Unlike BACCHUS and SUSSLE where they had regular scheduled meetings, NIS meetings and discussions were only scheduled when critical decisions or approvals were needed. This system encouraged individuals to act independently and in a self-motivated fashion. The boundaries and well-defined tasks created autonomy and efficient decision making as illustrated in the following quote.

"We engage and we discuss. The scientists trust my business experience and I trust their scientific knowledge. I presented strategically the issues that I saw with NIS that was going to be good for small businesses" (I47P29, pg.2).

The way interactions occurred in NIS is also explained by what Morgan (1986) calls the principle of 'minimal critical specification', which refers to defining as little as possible how a team should perform tasks, but provide just enough directives to ensure that its members are able to perform the tasks properly while still allowing for their own contribution. This principle is also explained by empowerment theory where the upper management defines only the critical factors, and the group members receive as much autonomy as they can handle, according to their knowledge and experience. It can be argued that NIS had decentralised control with high autonomy where self-organisation was key for autonomous decision making. The business development manager took a position of authority and with minimum directives was able to manage a successful team.

Even though an empowerment theory to explain an *adaptive self-regulation* mechanism implies power control, at NIS it comes across as a functionalist explanation, as there were individuals fulfilling functional requirements to get the project running. Individuals worked autonomously and were self-directed. The implications to IFR that scientists work in a self-organising, autonomous way are many and it can be seen as a viable means of increasing the competence of IFR and its scientists to deal with ever changing environmental demands. It is also important to note that scientists worked well independently and this concept of empowerment can also offer suggestions. Creating an environment that advances empowerment and improves communication with less role variability might be good suggestion for IFR.

7.4.4 LESS PREDOMINANT TRANSFORMATIONAL MECHANISMS

There were a few less predominant transformational mechanisms in the projects as summarised in Table 34. These mechanisms are still important to understand why knowledge transfer took place in these projects, but they do not appear to be the predominant ones. They are defined as *learning, negotiating, coordination* and *trust*.

Table 34: Transformational Mechanisms

Project		BACCHUS	SUSSLE	NIS
Transformational Mechanisms	Predominant	Aggregation	Learning	Adaptive self-regulation

	Less Predominant	Learning Negotiating	Negotiation Coordination	Trust Negotiating

Learning was the predominant mechanism in SUSSLE but it also played a part in BACCHUS, mainly reflecting the learning that took place during interactions among partners within meetings. Unlike in SUSSLE where it is argued that learning was the predominant mechanism, it takes a much smaller role in BACCHUS and it does not offer a convincing explanation to the interaction and actions of individuals.

Negotiating is a mechanism present in all projects. In BACCHUS, this mechanism was present during the decisions and discussions regarding dissemination routes and next steps. Similarly, in SUSSLE it relates to the various meetings and discussions that brought about decisions on the direction of the project and how they would disseminate the results to food manufacturers and the wider communities. In NIS, negotiating can be explained by the interaction of individuals in the early discussions and meetings on funding options for the project. Therefore, it can be argued that *negotiating* was a mechanism that promoted decision making but played a smaller part than the predominant ones.

Coordination is also present within SUSSLE and helps to explain the coordination of events and successful adaptation that partners had to endure during discussions and meetings. It could be argued that coordination and adaptation were responsible for the learning that evolved among partners. *Trust* was a mechanism in NIS that partly helps to explain an outcome. By trusting each other's decisions and capabilities, scientists and the business development manager were able to move the project forward in an effective way.

7.4.5 FURTHER CONCLUSIONS

The importance of actions and interactions to help explain knowledge transfer and the micro-macro link seems to be a particular part of this study's framework that is lacking from most of the knowledge transfer literature. However, it is a vital link that provides an explanation for why these interactions lead to an outcome.

An aggregation mechanism from a decision making angle suggests that formal procedures such as voting, and more adaptive procedures such as bargaining, had to come together for the BACCHUS project to bring about the outcome of dissemination and knowledge transfer. Thus, through the recognition of partners' commonalities and differences, the individuals managed to adapt to each other. The interactions in SUSSLE, although sometimes similar to

BACCHUS, were not driven by the same mechanism. It was through learning that partners exchanged knowledge between each other and though learning that SMEs absorbed the knowledge. This difference could be explained in two ways: (1) in BACCHUS most of the partners, both from industry and sciences, were already highly skilled and in tune with the benefits of bioactive compounds. Thus, the need to learn was not as strong as the case in SUSSLE. In SUSSLE, partners were not necessarily familiar with each other's skills or language, having only the same end goal. Thus, they had a longer learning process to achieve the outcomes. (2) The findings in BACCHUS were more directly applicable to the industrial partners, whereas in SUSSLE, the tools had to be taught through workshops to food manufactures from various subindustries, therefore the knowledge was transferred though learning.

The adaptive self-regulation mechanism in NIS explained by empowerment theory suggests a different repercussion than for the previous projects. In BACCHUS and SUSSLE, interactions among partners occurred often and were intense in discussion, arguing and learning. However, in NIS interactions were sparser and decisions were made more autonomously. Whilst BACCHUS and SUSSLE had a defined end date, NIS is currently in a continuous delivery mode, and could potentially become a spin-out company from IFR. This could explain why partners in NIS are more loosely coupled, but still make precise decisions within their own areas. Another point is that in NIS they hired a business development manager to progress the project. This external person joined a fairly well established research institute and brought his own way of working to the project. Although the other projects also had external partners, most of them have worked together in similar projects before.

Most of these mechanisms are also likely to be present in knowledge transfer relationships, particularly so in science-industry ones. Thus, the relevance of understanding and explaining interactions at a mechanism level can have important implications for management. These implications will be further explored in the next concluding chapter.

7.5 Conclusion

Knowledge transfer is a socially situated activity therefore individuals' motivations and beliefs (agency level), interactions (interaction level) and their environments (structure level) are important elements in understanding this process. This chapter has discussed the generative mechanisms at these different levels that were found within each project that was investigated in this study. For each section, it provided a summary of the project, a restatement on the mechanism, followed by an overview and critical discussion on how they relate to previous

literature. It also provided a theoretical explanation with micro and macro theories that help explain each of the mechanisms investigated. Some of the contributions and implications are summarised in Table 35.

Table 35: Discussion summary

	Structure	Agency	Interaction
BACCHUS			
Mechanism	*Incentive*	*Instrumental rationality*	*Aggregation*
Theory	Theory of compliance to social norms	Theory of reasoned action	Decision theory
Contributions	Previous literature views incentive as a motivational construct, mostly from an economic view, and as a tangible resource. This study finds incentive to be an intangible resource driven by social norms and social cohesion.	Previous studies look at motivations such as to further research, respond to economic opportunities, gain reputation or comply. This study suggests scientists are motivated by non-pecuniary reasons, using reputation as a tool. It suggests that scientists believe that they can add value and learn with industry. Scientists respond in an instrumental way.	Previous studies look at interaction elements such as communication, coordination, shared language, symbols, integration, and articulability. This study agrees and builds upon this. Aggregation, coupled with adaptation and feedback works for decision-making and individuals' interactions.
Contribution related to specific knowledge transfer literature	Ding et al. (2016) Lucas and Ogilvie (2006) Colyvas et al. (2002)	Lam (2011a) Owen-Smith and Powell (2001) Siegel et al. (2007)	Chung-Jen et al. (2014)
Implications	• Compliance sits at IFR's management level rather than with individual scientists • Financial incentives are not likely to work • Instruments that foster social relationships and interpersonal interactions are more likely to work	• An organisational environment conducive of transparency with a focus on scientists' belief systems is more like to be successful than a focus on industry engagement • Facilitative work environments seem to be more effective than forced rules and mandates.	• Decision-making can be facilitated by being sensitive and adapting to individuals' value systems, keeping context and customers' frame of mind as priorities • Uncertainty can be reduced by open communication channels such as feedback • Persuasion skills and political context sensitivity are important during interactions
SUSSLE			
Mechanism	*Reputation*	*Self-interest*	*Learning*
Theory	Trust theory	Self-determination theory	Community of practice theory
Contributions	Previous studies argue that reputation reduces monitoring and uncertainty. This research argues that reputation has a socially-embedded nature, where trust and networks are important.	Previous research motivations include securing funding, keeping team members, making fundamental research socially relevant. This study agrees and builds on that. Scientists' values and research relevance to society are strong motivators. Social-psychological needs are also important.	Previous studies look at learning as a variable that positively relates to knowledge transfer and organisational performance. Learning depends on absorptive capacity, peer similarity and shared reality. This study agrees and builds on these findings, also identifying group identity, sense of belonging, social interactions, shared goal facilitated learning.
Contribution related to specific knowledge transfer literature	Low and Robins (2014) Lucas and Ogilvie (2006)	Lam (2011a) Göktepe-Hulten and Mahagaonkar (2010)	Reagans and McEvily (2003) Bercovitz and Feldman (2008)

Implications	• Industry-relevant research helps build reputation • Social interactions and trust building exert influence on reputation • Association with high reputation networks and organisations allows for more successful funding applications.	Elements that should be considered when engaging with industry: - Autonomy: strategies to enhance scientists' autonomy, minimising control - Relatedness: provide choices of projects with applied focus - Competence: exposure to projects with subject familiarity	• Social interactions promote learning and engagement • Empowerment and commonality are important tools for individuals' interactions
NIS			
Mechanism	*Opportunity*	*Strategic calculation*	*Adaptive self-regulation*
Theory	Utilitarian compliance theory	Rational choice theory Cognitivist model	Empowerment theory
Contributions	Previous studies see opportunity from transaction costs and knowledge-based views. This study builds on these views and explains opportunity from a utilitarian compliance perspective.	Previous studies argue financial rewards play a small part and that scientists use their scientific, human and social capital. This study argues that scientists were financially motivated. Agree with scientific capital (databases), human capital (scientists and development manager) and social capital (networks). Also, motivated to retain National Capability position and perceived disruptive service.	Previous studies look at teamwork and its relation to autonomy, self-organisation, role variability and flexibility. This study builds on previous ones by emphasising individuals' autonomy and well-defined roles as facilitators of decisions and execution of tasks.
Contribution related to specific knowledge transfer literature	Coff (2003) Yam and Chan (2015) Helper et al. (2000)	Lam (2011a) Haeussler and Colyvas (2011)	Molina and Llorens-Montes (2006) Llopis and Foss (2016) Ozlati (2015)
Implications	• Instrumental approach to opportunity • Compatibility between research projects and industrial needs • Proactive approach in searching or meeting industry requirements	• Networks are key to tap into social capital and allow exposure • Scientific and human capital are important drivers for impact • Position and perceived value are important. Having a position to uphold such as National Capability proved to be a strong driver to engage with industry.	• Decentralised control and high levels of autonomy can work well when roles and tasks are well-defined • Communication channels such as meetings and discussions only for critical decisions can be an effective way to work as a self-organising team.

The BACCHUS project was driven by a situational mechanism of *incentive*, explained by a theory of compliance to social norms. Scientists responded in an instrumental way driven by an action-formation mechanism of *instrumental rationality*, explained by a theory of reasoned action. Scientists interactions were driven by a transformational mechanism of *aggregation* explained by decision theory. By uncovering generative mechanisms, these findings add to previous literature in many ways: they offer an explanation of incentives driven by social norms rather than economics; they offer an explanation for individuals' motivations driven by instrumentality and beliefs; and they offer an explanation for individuals' decision-making

through adaptation and aggregation to bring about the outcome of dissemination and knowledge transfer.

The SUSSLE project was driven by a situational mechanism of *reputation*, explained by a theory of trust. Scientists responded in a value laden way, driven by an action-formation mechanism of *self-interest,* explained by self-determination theory. Their interactions were driven by a *learning* mechanism, explained by community of practice theory. These findings add to previous literature by seeing reputation from a socially embedded nature where trust is an important element. It also considers the importance of psychological needs as a motivator for knowledge transfer and a sense of shared identity and belonging in facilitating learning for knowledge transfer relationships.

The NIS project was driven by a situational mechanism of *opportunity*, explained by a utilitarian theory of compliance. Scientists responded in a strategic way driven by an action-formation mechanism of *strategic calculation,* explained by rational choice theory. Their interactions were driven by an *adaptive self-regulation* mechanism explained by empowerment theory. This study builds on previous literature by explaining opportunity from a utilitarian compliance angle, the importance of non-pecuniary rewards such as position and status as motivators to knowledge transfer, as well as autonomy and well-defined roles for successful decision-making.

8 CONCLUSION

This study commenced with the observation that the food industry is facing societal challenges which are too complex to be tackled by individual organisations. IFR seemed to be geared towards advancing solutions to these societal challenges with a range of partners and funders, and this sparked the motivation for this research. The aim of this research was to understand how and why knowledge is transferred from IFR to the food industry. The motivation behind this study is to contribute to a deeper understanding of science-industry knowledge transfer, by offering a mechanismic explanation via a process-tracing approach and a critical realist lens. This kind of explanation of a phenomenon reveals the mechanisms that underlie it. This distinctive form of explanation has enabled the understanding of many important aspects of explanatory research, illuminating many overlooked characteristics of knowledge transfer.

The focus of this research, on generative mechanisms in multiple projects, marks an advance over earlier methodologies and theorising. Rather than employing vague notions of relationships between variables, the theorisation has been on knowledge transfer mechanisms such as reputation, instrumental rationality and aggregation. The combination of micro and macro perspectives complements and adds to the knowledge transfer literature by delving into a deeper ontological layer. In addition, this research develops arguments based on novel theoretical perspectives and how these influence practice. This research is also problem-driven, which leads to a pragmatic understanding and the potential for the future development of middle-range theories to enrich the knowledge transfer literature.

The study not only contributes to research on science-industry knowledge transfer, but also has important implications for policy makers seeking to promote the commercial exploitation of research. In particular, it demonstrates that there is no single ideal type of project, motivation or interaction that makes knowledge transfer successful. It is therefore unlikely that an undifferentiated approach will be effective in eliciting the requisite effort across stakeholders.

The contributions of this study are that it:

- Provides a novel application of a methodology for the knowledge transfer literature and management in general, that helps to capture and describe generative mechanisms;
- Provides a mechanismic explanation for science-industry knowledge transfer;
- Provides a fine-grained framework that includes macro and micro levels of analysis.

The next section revisits the research questions and summarises this study's findings presented in the previous discussion chapter. Next, theoretical and methodological contributions are summarised. Lastly, this study's limitations and recommendations for future research are suggested.

8.1 RESEARCH QUESTIONS AND FINDINGS

Research Question: how and why knowledge is transferred between a food research institute and industry in the UK?

Knowledge is transferred through the interactions of individuals using, for example, tools and software, workshops, meetings, debates, discussions, reports and training sessions. There are also various reasons why scientists transfer knowledge such as: to produce more research, to be nearer to the market and consumers, to learn and exchange knowledge, to fulfil industry needs, to retain staff, to further business opportunities, and to produce impact.

Objective 1: To reveal the generative mechanisms that are driving knowledge transfer between IFR and industry to address this sector's challenges.

There are nine predominant mechanisms driving these three projects which were discussed in the Findings and Discussion chapters. The situational mechanisms are *incentive, reputation* and *opportunity* whilst the action-formation mechanisms are *instrumental rationality, self-interest* and *strategic calculation.* The transformational mechanisms are *aggregation, learning* and *adaptive self-regulation*. The contributions and implications of these mechanisms (and also the less predominant mechanisms) are explained in detail in the Findings and Discussion chapters.

Objective 2: To develop a contextualised explanation of how and why knowledge transfer takes place.

The contextualised explanation of why and how knowledge is transferred from IFR brings to the fore that the structural environment is an important contributing factor that facilitates knowledge transfer within these projects. Structural constraints in the BACCHUS and SUSSLE projects, such as impact agenda pressures, limited funding and restricted reachability to consumers were driven by reputation and incentive mechanisms rooted in social norms and trust, whilst in the NIS project, the structural opportunity of owning a strategic database and maintaining a position as a National Capability were driven by an opportunity mechanism to comply.

Although all projects proved to be driven from rational type mechanisms at the agency level, the explanation is different. BACCHUS scientists were instrumentally driven to apply their research, whilst SUSSLE scientists were value driven to fulfil intrinsic motivations, and NIS scientists were strategically driven to maintain a position and generate financial opportunities.

At the interaction level, BACCHUS was driven by an aggregation mechanism where individuals had to adapt to each other's decision making and work together to achieve the outcome of dissemination to SMEs. SUSSLE was driven by a learning mechanism where individuals had to learn from each other to develop specific tools for industry. At NIS, individuals had well-defined roles and tasks and worked autonomously, driven by an adaptive self-determination mechanism.

8.2 ORIGINALITY AND VALUE

This study provides a novel, empirically grounded framework to explain knowledge transfer that allows researchers and practitioners to reinterpret the existing literature in a way that integrates findings on the impact of rules, norms, motivations, beliefs and interactions. This innovative framework is a vehicle to understand generative mechanisms and can be applied to various disciplines. The lens of critical realism and its stratified ontology offers a complementary view to mainstream positivists' studies and the process-tracing methodology offers a robust analytical means to explain phenomena. It offers a unique set of empirically grounded mechanisms that have not been investigated before in the knowledge transfer literature. Moreover, it provides a nuanced view of knowledge transfer that advances current studies by offering a robust explanation with strong theoretical underpinnings.

8.3 THEORETICAL CONTRIBUTIONS

This study yields a number of theoretical contributions that build upon and clarify prior research. First, there is a contribution to the knowledge transfer literature. By unpacking the micro-foundations, the interactions and the macro influence on each project, this study provided an in-depth mechanismic explanation that previous research did not offer. This kind of explanation has different contributions to theories and provides different implications for management. Thus, the implications of these findings are more robust and theoretically stronger.

Whilst previous research explored knowledge transfer from specific theoretical angles or considered different variables that influence knowledge transfer and organisational performance, this study inductively investigated knowledge transfer projects from events and

narratives through to its generative mechanisms. Therefore, it is now possible to work at a mechanism level. For example, instead of explaining that knowledge transfer is positively influenced by scientists' entrepreneurial commitments, this study goes further to argue that entrepreneurial commitments are driven by *rational-type* mechanisms which are rooted in individual's motivations and beliefs and can be explained by different micro theories.

With previous explanations, the implications would lie in developing entrepreneurial incentives for scientists such as bonuses for engaging with industry. This study argues that the implications lie in understanding why scientists are motivated and understanding their belief systems. In the case of BACCHUS, it is driven by instrumental rationality and the implications are related to scientists' belief systems and a facilitative work environment, rather than a focus solely based on economic opportunities or reputation. SUSSLE presented similar motivations with the added focus on autonomy, relatedness and competence. In NIS, scientists were financially and status motivated however they could only achieve that because they had strong social and human capital.

Similarly, structural conditions influenced the projects in different ways. Previous research has viewed incentive as a tangible resource and from an economic angle. This study finds that incentive in BACCHUS is an intangible resource driven by social norms and social cohesion. The implications of this view are that a focus on social relationships and interpersonal interactions are more important than financial rewards. Likewise, the opportunity mechanism in NIS has been explained from a transaction costs angle, whilst this study explains opportunity from a compliance perspective. The implications of this view are that similarity between research project objectives and industry needs seem to be more important than taking advantage of an opportunity purely for financial gains. The identification of reputation as important within the SUSSLE project also builds on previous studies. Whilst there is agreement that reputation reduces uncertainty in knowledge transfer, this study adds that reputation has a socially embedded nature rooted in interpersonal trust. Similar to NIS, industry-relevant research helps to build reputation and social interactions facilitate trust building.

The interaction among individuals and how they make decisions in knowledge transfer relationships is often viewed in a linear way within previous research. This study's findings view these interactions much more dynamically. In BACCHUS, aggregation meant that individuals had to adapt to each other's styles of decision-making, which means persuasion skills and sensitivity to others value systems are important implications for management. In SUSSLE, learning was the driving mechanism, which means a sense of belonging and group identity are important. Building social interactions and having common end goals facilitate

engagement and learning. In the NIS project, an adaptive self-regulation mechanism means that autonomy and decentralised control facilitate knowledge transfer. The implications for these kinds of independent interactions are that communication channels should be transparent and well-defined roles and tasks help with clarity and effective execution.

In much of the literature there is a proliferation of macro level constructs and perspectives which can be problematic because the micro-mechanisms that influence knowledge transfer and its outcomes are not identified and observed. By grounding the knowledge transfer debate in a more robust framework that bridges macro and micro levels, this study also contributes to the emerging body of literature on mechanismic explanations. Another theoretical contribution of this study is related to the perspective on knowledge transfer. Most previous studies use gap spotting and look at knowledge transfer from the industry's perspective with a strong focus on organisational performance. This study looks at knowledge transfer from IFR's and the scientists' perspectives, with a focus on the problematisation of wider societal challenges in the food industry.

8.4 Methodological contributions

There is no ready-made template for how to conduct a critical realist study. The challenge to find a methodological pathway towards a plausible explanation was a process of discovery. In the beginning, a case study approach seemed to be a good option, however the positivist underpinnings of traditional scholars such as Yin (2009) and Eisenhardt (1989) did not fit the mechanismic explanation proposed in this research. The methodological process that emerged differs from previous studies on four key points: (1) process-tracing as the methodological approach; (2) critical realism as the philosophical lens; (3) mixed analytical methods applied; and (4) multiple levels of analysis whereby the outcomes at one level shape the context of the next. Each point will be briefly highlight in the following sections.

***Process-tracing as the methodological approach*:** This study has used process-tracing as the methodological approach to investigate generative mechanisms. Process-tracing is an approach often used in the social sciences, particularly in political sciences (Mahoney, 2000, Collier, 2011, Bennet and Checkel, 2015). Process-tracing has been used predominantly to help to explain historical cases such as the European Integration (Pierson, 1996, Schimmelfennig, 2015) and democratic peace (Layne, 1994), by offering either a temporal or analytical analysis which links the events to explain the outcome. It adds inferential leverage and depth that are often lacking in quantitative analysis. The process of identifying the causal group for each of the projects investigated differs from a traditional case study. Rather than

selecting participants on the basis of their specific position (e.g. only research leaders) or their membership to a taxonomic group (e.g. male scientists in senior positions), participants were individually selected on the basis of the role they played within the causal group. This group is progressively discovered, mapped and approached. In the end, the causal group involved scientists, managers, lawyers, SMEs, retailers, funders, and research leaders.

The process of formulating questions and deciding what other evidence to collect from documents and observations was not structured around a pre-determined protocol, but evolved with the understanding of the projects. The objective was not only to determine how knowledge transfer had taken place, but also why it had taken place. The search was not for one converging story or chain of events, but for one converging explanation based on multiple sources of evidence. Interviews were loosely structured around the core question of how things happened and why, but often deviated from the script by going deeper into some specific parts or events of the projects that the participant had been particularly involved in. Selection of additional material was on the basis of its possible explanatory contribution. Some documents therefore became important pieces of evidence whilst others were collected more as a matter of routine (e.g. financial reports from IFR and BBSRC) to see if they could offer further insight.

In conclusion, process-tracing differs in nature from traditional case studies, and poses some specific challenges when implemented for the purpose of analysis of different ontological layers. The process is time-consuming and sometimes difficult to plan ahead. It often merges the process of data collection with the process of data analysis and the plethora of theoretical explanations for each of the mechanisms is a painstaking analytical process. This study has opened the way for more use of process-tracing and mechanismic explanatory research to take place not only in knowledge transfer but also in general management literatures.

***Critical realism as philosophical lens*:** The contribution of a critical realist study does not lie in patterns of regularity, but in unmasking the underlying mechanisms in a specific context that explain why and how a phenomenon unfolded. Adopting a critical realist perspective to view, examine and explain knowledge transfer also allows a particular vision into the different levels of reality. This process of discovery is possible by using multiple methods and theories to come to the most plausible explanation. Structures and agents have causal powers, and these powers need a particular context to become exposed.

The framework of critical realism shaped how this research was approached, including the kind of questions asked in interviews and how data were analysed to produce plausible explanations. One of the ways of analysing mechanisms was to treat the first ontological layer

as what prior studies called variables or antecedents, and then moving beyond the first ontological layer into deeper layers, where the mechanisms are located. Unlike methodological individualists, critical realists are also emergentists who argue that higher-order strata of social reality emerge out of lower-order ones, and that events within those emergent strata are caused by mechanisms. These assumptions are complex and come from the premise that individuals are social beings who act based on previous experiences and prior social interactions.

It is not a straight forward task to reach different layers of reality. For critical realists, like Bhaskar (1979) and Collier (1994), the search for mechanisms is the *sine qua non* of social sciences. In their view, the identification of mechanisms involves analytic movement across three ontological domains: from the empirical, to the actual and finally the real domain, wherein lie the causal mechanisms. In this study, the empirical domain is where scientists access their experiences in the projects. The actual domain is where scientists identify the events that generate that experience. Thus, from the interviews, documents and observations it was possible to develop a narrative that explained knowledge transfer within each project The real domain is where, through analytical reasoning, the predominant mechanisms were abstracted. A further analysis into macro and micro theories that help explain the mechanism formed the last analytical phase in this study.

Through critical realism, it is possible to conclude that the literature on knowledge transfer is poorly understood, not because the discipline lacks a paradigm, but because it only has one paradigm. The understanding of causality and explanatory studies in this field are limited to relational views and positivist assumptions. Thick descriptions are rare and mechanismic explanations are non-existent. This scant attention to different worldviews leads to shallower theoretical interpretations and debates. Both in practice and in academia, this narrow paradigm leads to conflict between what is right and what is wrong, instead of to more open debates about ideas.

Mixed analytical methods applied: To move beyond the actual ontological domain to the real domain, where mechanisms that drove knowledge transfer were abstracted, it was necessary to apply different analytical methods at each stage. Traditional content analysis was used to find the themes around the norms, rules, resources, motivations, beliefs and interaction, and abductive reasoning and systematic combining were employed to find plausible explanations and theoretical underpinnings. First, to explain the knowledge transfer process for each project, a narrative explanation was developed taking into account the structure, agency and interaction levels. Then, though abductive reasoning, a range of mechanisms traditionally

found in sociology literature were used to help derive the most plausible explanation for each project. This phase provided both the predominant and less predominant mechanisms described in the Findings chapter. Finally, through systematic combining, an iterative process of linking the mechanisms to the extant body of theories was undertaken to find a suitable theoretical explanation for each mechanism.

***Multiple level of analysis*:** A contextualised explanation implies that the phenomenon under investigation needs to be analysed as an open system. Whilst previous studies either investigate knowledge transfer from one theoretical lens or are focused on one level of analysis, this study demonstrates that structural forces, agents and their interactions all influence the projects differently. As explained in the Methods chapter, using a multi-level framework and taking insights that individuals make decisions depending on specific structural factors, allow these individuals to follow a different motivational logic which influences outcomes. This process of an explanation seeking project can only be solved by understanding the mechanisms at all levels.

8.5 PRACTICAL CONTRIBUTIONS

Beyond the theoretical and methodological contributions, the effects uncovered in this study are also meaningful from practical and managerial standpoints. These contributions are important both conceptually and practically because these projects represent a large proportion of science-industry interactions. The situation in which IFR finds itself today is that both the financial and impact pressures exerted by its ecosystem force it towards an efficiency seeking which sometimes does not fit individual scientists' motivations and beliefs. As IFR responds to these pressures with stricter funding requirements and a more centralised organisation such as industry engagement through its technology transfer office (TTO), sometimes autonomy, decentralisation and social rewards play a stronger part in industry engagements. If IFR decides to deny the importance of micro-foundations and macro mechanisms such as the ones presented in this study, it could risk losing its position within its wider ecosystem. Yet, by responding to them, IFR could work around the implications of these mechanisms, thereby constantly increasing its strength.

It is important that scientists and managers understand how the combination of structural constraining and enabling elements, together with individuals' motivation and beliefs and how they interact, bring about knowledge transfer. This recognition implies that knowledge transfer is not a socially neutral process and careful attention should be given to the social context within which knowledge transfer efforts are taking place. For example, incentive from a

compliance theory and social norm angle is intangible and there is a need to focus attention on social networks rather than simply focusing on financial compensation. Another practical implication relates to avoiding a premature implementation of new policies and norms within IFR. Most of the previous research on science-industry knowledge transfer does not provide any mechanismic evidence. Yet without such information, new policies and rules could potentially work against industry engagement.

A further practical implication relates to individuals' motivations and beliefs and how these influence knowledge transfer. Ackroyd and Fleetwood (2000) argue that the effect of agency becomes less obvious as the scale of the organisational structure increases and thus becomes more difficult to influence. In other words, structures become less susceptible to agency-driven transformation as they grow in scale. As IFR becomes the Quadram Institute of Biosciences (QIB) from April 2017, structural changes are bound to take place and its organisational size and identity will change and will influence scientists' existing motivations and beliefs.

8.5.1 POLICY IMPLICATIONS

One of the central challenges for policy is to obtain a deeper understanding of the mechanisms that improve knowledge transfer relationships and expose their value, whilst also distinguishing generic factors from those that arise from unique projects. This, in turn, should lead to more informed contributions to public policy-making and, arguably, to more effective support for organisations that work with various disparate stakeholders. Whilst correlation between variables might be significant, they can be problematic for manipulation by policy-makers. For example, policy that emphasises commercialisation obscures the fact that industry engagement with academic research often generates considerable benefits that can come from social interactions. The merging of scholarship and commerce has implications for public policy and a permissive policy stance based on transaction costs theories (Williamson, 1975) can be questioned. Rather, a construction of relationships based around social norms, autonomy and relatedness are suggested to be more optimal in science-industry knowledge transfer relationships.

Public policy often seeks evidence-based research findings. Typically, researchers approach to evidence is to carry out experiments, where the researcher controls the treatment, holding all other factors constant. Yet they frequently fail to show through which mechanisms these policies operate. Thus, another strategy in providing evidence to policy is to identify causal mechanisms that explain an outcome. An empirical method using this strategy includes process-tracing. However, without sufficient mechanismic evidence, it is difficult to determine

whether a given policy in its target environment will be effective and robust. Using a mechanismic explanation for science-industry knowledge transfer leads to a different view of scientists, and of IFR and its wider environment. For example, if it is assumed that scientists draw from social norms and act in an instrumental way to solve problems, national policy may be developed differently. Considering how national policies support or undermine the norms of reciprocity and incentives could offer more satisfactory knowledge transfer results. A reliance on solely improving access to funding is likely to be of limited effectiveness in increasing science-industry engagement, whereas an increased emphasis on tackling research compatibility may be more fruitful.

Another implication for policy relates to how Research Councils assess institutes' progress and performance. For example, currently BBSRC utilises the Institute Assessment Exercise (IAE) every five years. One of the items within this assessment is related to the institutes' achievements in knowledge exchange and commercialisation (KEC). KECs have a strong focus on direct financial impact through commercialisation and support in economic competitiveness. From the findings in this study, a strong focus on economic competitiveness could work against KEC activities unless non-pecuniary incentives such as relevance, morality and status are also taken into account.

8.6 LIMITATIONS

The findings of this study must be interpreted in light of its limitations. The first restriction of this study is its limitation to a single setting – IFR in the UK. Other research institutes and other countries with different policies represent a different context and accordingly the findings could be different. Just as scientists displayed a certain attitude to transfer and share their knowledge, the recipients, in this case mainly food manufacturer SMEs, may have an attitude towards the knowledge they receive and their willingness to accept it. This study looked at the process from the scientists' perspective, whereas if looked at from the SMEs perspective, the mechanisms are likely to be different. Moreover, the norms and rules derived from the current organisational environment at IFR are constantly changing and the effects of these changes were not studied during this research.

This study focused on different levels of analysis which potentially affect knowledge transfer behaviours and attitudes and its strength comes from the combination of these levels. However, it is not easy to identify which mechanism or which level of analysis has a stronger influence or is significantly more important than another. Are individuals' beliefs and

motivations a stronger determinant of knowledge transfer or are their interactions more important?

Another limitation is related to the methodological approach. Process-tracing presupposes the existence of theoretical frameworks. The suggested generative mechanisms, although firmly based in generally accepted theories, could only be inferred but not tested. These frameworks are supposed to guide the researcher in their approach, as in the analysis. One limitation is that either those theoretical frameworks are lacking, or they are ill-suited, leaving the researcher vulnerable to biases or forced to use an ill-adapted theory. When a theory does exist, it is often insufficiently specified and rarely tailored to the problem at hand. In this study, although an engagement in theory through systematic combining was a significant contribution, it is fair to say that there were parts of theories that were used to explain the various mechanisms, and not a single theory was found to be all-encompassing.

It was never the intention of this research to look for an absolute truth neither to generalise knowledge transfer mechanisms. However, to produce a plausible explanatory account, it is essential to see through the clutter of data and look for the mechanisms underneath. This is an important way to move a field of research forward and achieve excellence. Mechanisms are only made 'visible' through abstraction and analytical attention. This abstraction, by nature, accentuates certain aspects of an event or dispositions, and ignores others, which means that the explanatory nature of this research is highly linked to context, and the researcher's own judgements and views on the materials analysed. Although this study has borrowed generic mechanisms from social sciences, ideally it should have created its own mechanisms with specific descriptions and meanings.

Another limitation is the number of projects and the time when they occurred. Even though BACCHUS and NIS are more recent projects, SUSSLE happened in 2012 therefore how accurately scientists are able to remember events could be questionable. Another point regarding the limited number of projects is related to the number of mechanisms. There would be more mechanisms if more projects were investigated. In this study, 21 mechanisms were abstracted and 9 of them were predominant.

A further limitation of this study is the generalisability of findings. Although process-tracing offers strong internal validity due to its in-depth nature, it offers weak external validity, therefore the generalisation of the findings is poor. This is the main trade-off in pursuing a mechanismic explanatory study rather than a regularity or counterfactual one. Thus, process-tracing is not conducive to the development of generalisable theories because mechanisms are constituents

in specific cases. Nonetheless, analytical generalisability is possible. Thus, it can be argued that the 9 predominant mechanisms found in this research are likely to be present in other science-industry knowledge transfer relationships or public-private relationships. As previously discussed, research institutes are quite similar in that they depend on external funding to further their research, they are under the scrutiny of either research councils or similar funding bodies; and they belong to extensive networks and affiliations.

Another limitation is related to the empirical sources and their treatment, as findings may well be vulnerable to the threat of biases. For example, cognitive bias can alter the researcher's reasoning and skew the results. This bias can affect how the researcher plans to collect information, what she pays attention to, and what she reports. The results of process-tracing might be consistent with too many theories. It then becomes difficult to assess whether alternative explanations are complementary or if some are just spurious. Negative evidence might be ignored since positive evidence is more striking and vivid than its absence. In tracing the process, the researcher might overlook the things that do not happen. Interviewees and document evidence can also be affected by biases. Most of the documents analysed came from IFR, the projects' dissemination channels or BBSRC, which will offer evidence according to their perspective and demonstrate what they think is important. Interviewees were asked questions that were thoughtfully posed in a way that allowed them to reveal their true accounts without distortions. However, human elements of the research process could have affected their answers such as their true beliefs and motivations to engage with industry.

8.7 FURTHER RESEARCH

This study has made significant contributions both theoretically and practically. At the same time, it has paved the way for future research on knowledge transfer and management studies in general. Given the limitations presented in the previous section, future researchers should elaborate and extend the findings presented here into other contexts, such as other research institutes or science-industry knowledge transfer relationships. Another opportunity for future work is to test the mechanisms found in this study. One way of testing them would be to use process-tracing empirical tests of causal mechanisms such as Bayesian logics and doubly decisive methods (Beach and Pedersen, 2013). If such testing strengthens the results from this study, this could have an even greater impact on policy-making, positioning of future public funding and prioritisation of actions for industry engagement.

Cross-sectional data do not rule out the possibility of alternative causal pathways. Hence, future research using experimental or longitudinal designs is recommended to examine the

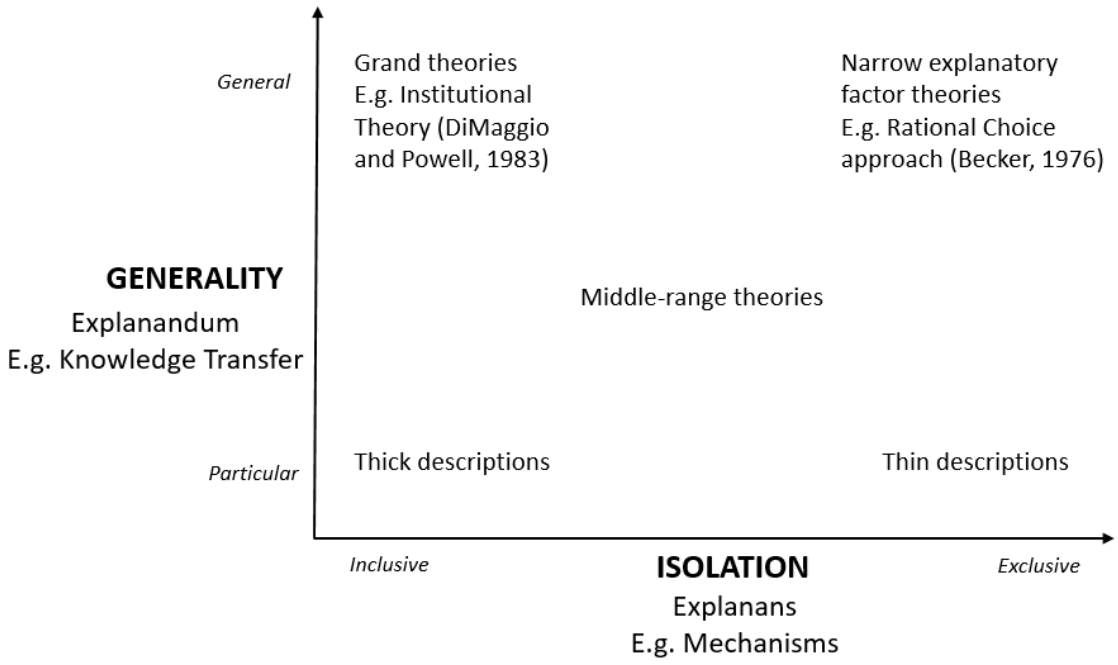
direction of causality. Ethnography studies would offer an excellent approach for longitudinal research in knowledge transfer. A contextualised ethnographic study that explores further the mechanisms outlined in this research would offer a detailed explanation of the effects of industry engagement over time. Also, it would be interesting in that research would then be reconnected with large-scale quantitative survey data in order to provide a more complete picture. More specifically, there are two areas which have been especially neglected by researchers and should be priorities for future studies. First, there is scant information on how knowledge transfer processes evolve over time, and how they interact with alleged outcomes. Second, mechanismic explanations differ from mainstream approaches employed in management studies: the positivist "covering law" statements and the interpretive hermeneutic or phenomenological approach.

Other areas for future work include the investigation of knowledge transfer mechanisms from the food manufacturer SMEs' perspective. This would give an all-inclusive explanation for why knowledge transfer happens and how a combination of perspectives could influence policy-making. Several findings in this study would be worth pursing in further studies, such as the role of social norms in driving knowledge transfer relationships at the macro level and the identification of patterns in belief-formation processes at the micro-level. What needs to be explained is not concrete action or single individuals, but the typical actions of typical individuals or why certain groups or categories of people act in certain way. Beliefs are often biased and flawed, and they are not always random and unpredictable, so the identification of patterns of beliefs-formation processes would provide a middle ground between universal general statements and subjective approaches. Such a study could be approached by observation methods and categorisation.

8.7.1 TOWARDS A MIDDLE RANGE THEORY

One way to further research from this study would be to develop a middle-range theory for knowledge transfer. Merton's (1967) notion of middle-range theory (MRT) is one of the most important contributions to analytical sociology. Middle-range theory emphasises the importance of tightly linking micro and macro levels to one another, together with the noteworthy role of endogenous social dynamics. The theory of self-fulfilling prophecy (Merton, 1948) is an example of a middle-range theory that isolates a few explanatory factors and highlights the heart of the story. The main notion of a middle-range theory is that it sits somewhere between general theories, as summarised in Figure 33.

Figure 33: Middle-range theory based on Merton's model (1967)



As noted in Figure 33, theories are explanations that consist of two main components: the explanandum, or what is to be explained, and the explanans, or that which explains the explanandum. If we refer to Figure 33, the explanans are situated on the horizontal axis with the concept of isolation. Isolation was introduced by Mäki (2004) and consists of focusing the attention on certain explanatory factors at the expense of others. For example, if the set of possible explanatory factors consists of (a, b, c, d, e, f) and the focus is on (a, b), that means an isolation was performed. In the case of the projects investigated in this study, the explanans are the various mechanisms abstracted from the data. By isolating the predominant mechanisms of each project (a, b, c), the less predominant mechanisms have been excluded (d, e, f), which helps in developing an explanation.

A similar distinction can be made to the explanandum, which is the vertical axis. This dimension refers to how general the theory is, as opposed to its specificity. The larger the set of phenomena or types of phenomena a theory can explain, the more general it is. For example, institutional theory (DiMaggio and Powell, 1983) and systems theory (Parsons, 1951) are examples of all-encompassing theories. A middle-range theory for the case of this study would probably be limited to only explain knowledge transfer that is set in science-industry relationships.

From the MRT perspective, a theory can be regarded as a system of propositions, which can be reduced to a number of testable hypotheses. A theory is not testable in itself, only indirectly

by hypotheses derived from the theory. In this study, in order to find the generative mechanisms for each project, abstraction from the data has been performed. The difference between the abstract and concrete is not a matter of distance to reality, quite the contrary. It is a matter of involving varying degrees of isolation and complexity, not to cover complexity but to explain it in a simple way. This study has done this abstraction by identifying the necessary constituents' elements for each project, such as the structural constraints and opportunities, individual's motivations and beliefs, their actions and interactions. A further step from this study would be to develop a middle-range theory of science-industry knowledge transfer. In order to achieve that, further empirical investigation would be necessary, both to observe further mechanisms and to test current ones. For example, mechanisms such as power and coercion could surface after further rounds of interviews. Also, systematic observations would offer further insights into developing a middle-range theory.

An ideal theory of the middle range is clear, precise, and simple. It does not bore the reader by attempting to describe the causal process in all its detail; instead it seeks to highlight the heart of the story by isolating a few explanatory factors that explain important but delimited aspects of the outcomes to be explained. Thus, the development of a middle-range theory from a mechanismic explanation forms a promising future approach for integrating empirical analysis and theory construction in the knowledge transfer literatures.

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APPENDICES

APPENDIX 1: OVERVIEW OF SOME KEY STUDIES ON KNOWLEDGE TRANSFER

Authors	Study Type	Level of Analysis and Focus	Key Findings
Knockaert et al. (2011)	Qualitative (longitudinal case study, interviews).	Organisational level. Focus on performance.	In the creation of academic spin-offs, commercial expertise-mindset and tacit knowledge is most effectively transferred when a substantial part of the original research team joins the new venture as founders.
Grant (1996)	Theoretical.	Organisational level.	The knowledge-based view of the firm sees access to, and the development, protection and transfer of knowledge as a means of creating and preserving competitive advantage.
D'Este and Perkmann (2011)	Quantitative (survey).	Individual level. Focus on individual motivations (micro).	Most academics engage with industry to further their research rather than to commercialize their knowledge.
Göktepe-Hulten and Mahagaonkar (2010)	Quantitative (survey).	Individual level. Focus on understanding scientists' patenting activities and motivations.	Researchers engage in patenting not for personal profit but to signal their achievements and gain reputation amongst their academic and industry-related communities.
Lam (2011b)	Mixed (interviews, regression analysis)	Individual level. Focus on diversity of motivations by adopting a broader and psychologically richer notion of motivation - extrinsic as well as intrinsic aspects.	There is a diversity of motivations for commercial engagement, and that many do so for reputational and intrinsic reasons and that financial rewards play a relatively small part.
Reagans and McEvily (2003)	Quantitative (survey).	Organisational level.	Social cohesion and network range ease knowledge transfer, over and above the effect for the strength of the tie between two people.
Zaheer et al. (1998)	Mixed (interviews, questionnaire, structural equation model)	Individual level concept of trust to the organizational-level outcome of performance.	Trust - interpersonal and interorganisational - in exchange relations clearly matters.
Kachra and White (2008)	Quantitative (policy capture).	The effect of different contextual cues - competitiveness, social relationship, firm boundaries - upon the know-how transfer.	Supports a general theory of reciprocity whereby social, competitive, and firm boundary cues have a summative effect upon the expectation of reciprocity and know-how transfer.
Samieh and Wahba (2007)	Quantitative (questionnaire).	Individual level.	Individual's knowledge sharing behaviour is driven by a set of salient beliefs that are not unlike the notion of payoff in game theory.

Muthusamy and White (2005)	Quantitative (archival and survey-based regression analysis).	Organisational level.	The greater the reciprocal commitment, the greater the degree of leaning accomplished.
Lam (2007)	Qualitative (interviews).	Organisational level. Focus on R&D projects between firms and universities and forms of career models that support knowledge flows	Incentives for scientists to engage in industrial ventures to support research are most salient in the Anglo-American context with its pluralistic forms of research competition and funding structure.
Chung-Jen et al. (2014)	Quantitative (survey).	Organisational level. Process-oriented view and cooperation angle.	Transfer mechanisms relate positively to cooperative competency with partnering firms, which then improves knowledge transfer performance.
Inkpen and Tsang (2005)	Conceptual.	Organisational level.	Each network type has distinct social capital dimensions and facilitating conditions vary across networks. For effective and efficient knowledge transfer, firms must build social capital proactively.
Santoro and Saparito (2006)	Quantitative (survey).	Organisational level. Focus on self-enforcing safeguards of self-interest assumption and relational trust.	Both self-interest assumption and relational trust are positively associated with greater knowledge transfer. As knowledge becomes more tacit, self-interest assumption becomes negatively associated with knowledge transfer while relational trust becomes more strongly positive.
Santoro and Saparito (2003)	Quantitative (survey).	Organisational level.	A firm's trust in the university research centre was positively associated with knowledge and technology transfer. Firm's geographic proximity to their university partner was positively related to the firm's trust.
Argote and Ingram (2000)	Conceptual.	Organisational level.	In order for knowledge transfer to be successful, the knowledge reservoirs or subnetworks imported from one context must be compatible with or fit the new context.
Gopalakrishnan and Santoro (2004)	Quantitative (cross-sectional analysis; two-step survey)	Organisational level.	Firms with more mechanistic structures and more stable direction-oriented cultures were associated with higher levels of knowledge transfer. Conversely, firms with more organic structures, more flexible change-oriented cultures, and more customized university policies for IPR, patent ownership, and licensing were associated with higher levels of technology transfer.
Darr and Kurtzberg (2000)	Mixed.	Organisational level.	"Strategic similarity" (similarity of the strategies and tasks) positively affected transfer of knowledge, whereas similarity of customers or location had no effect.
Szulanski (2000)	Quantitative.	Organisational level. Focus on KT process stages and stickiness.	Factors that affected the perception of an opportunity to transfer knowledge, such as the reliability of the source, predicted difficulty of transfer during the early initiation stage, whereas factors that affected the execution of transfer, such as the recipient's ability to absorb knowledge, affected difficulty during the implementation phases.

Williams (2007)	Quantitative (survey).	Organisational level.	Replication and adaptation lead to successful knowledge transfer, which leads to improved performance. Firms replicate more when knowledge is discrete and adapt more when they understand the interactions between different areas of knowledge.
Lee and Cavusgil (2006)	Mixed (interviews and survey questionnaire).	Organisational level. Focus on relational perspective of trust.	Relational-based governance as opposed to contractual-based governance is more effective and influential in strengthening the interfirm partnership, facilitating KT.
Kotha et al. (2013)	Quantitative.	Organisational level.	Anticipated coordination costs arising from KT to licensee firms and from the need for an inventor team's members to work together to further develop a technology significantly impact commercialization outcomes.
Blumenberg et al. (2009)	Qualitative (case studies).	Organisational level.	Transfer processes for explicit knowledge consist of two dimensions: the content dimension, which defines how content has to be interpreted, and the sender–receiver dimension of transfer, which defines interaction structures between parties. The combination of processes designed to transfer explicit and tacit knowledge has the most influence on the level of shared knowledge.
Owen-Smith (2003)	Quantitative.	Organisational level.	Network relationships with industry enable institutions to develop higher impact patent portfolios, but too tight connections limit patent impact.
Liyanage et al. (2009)	Conceptual.	Organisational level.	The number of steps taken in a knowledge transfer process can be diminished if the source and the receiver are similar either contextually, technically, or structurally.
Jensen and Thursby (2001)	Quantitative (survey, game theoretical modelling)	Organisational level.	Lump-sum payments do not provide an incentive for the inventor to continue putting efforts into the development of the invention after licensing agreements are signed.
Colyvas et al. (2002)	Qualitative (case studies)	Individual level.	Financial incentives play little or no role in motivating faculty to involve in invention-yielding research projects; professional interests of researchers were more relevant.
Markman et al. (2004)	Mixed (interviews, survey, database)	Organisational level.	Monetary rewards to TTO staff are positively related to equity licensing and to firm creation, royalty payments to scientists and their departments are negatively related to university based technology transfer.
Bercovitz and Feldman (2008)	Mixed.	Organisational level.	Different organizational forms of technology transfer offices (information processing capacity, coordination capability and incentive alignment) affect technology transfer performance.
Owen-Smith and Powell (2001)	Qualitative (interviews)	Individual level.	Scientists' invention disclosing decisions depend on their perceptions of the costs of interacting with TTOs and licensing professionals.

APPENDIX 2: SAMPLE INTERVIEW QUESTIONS

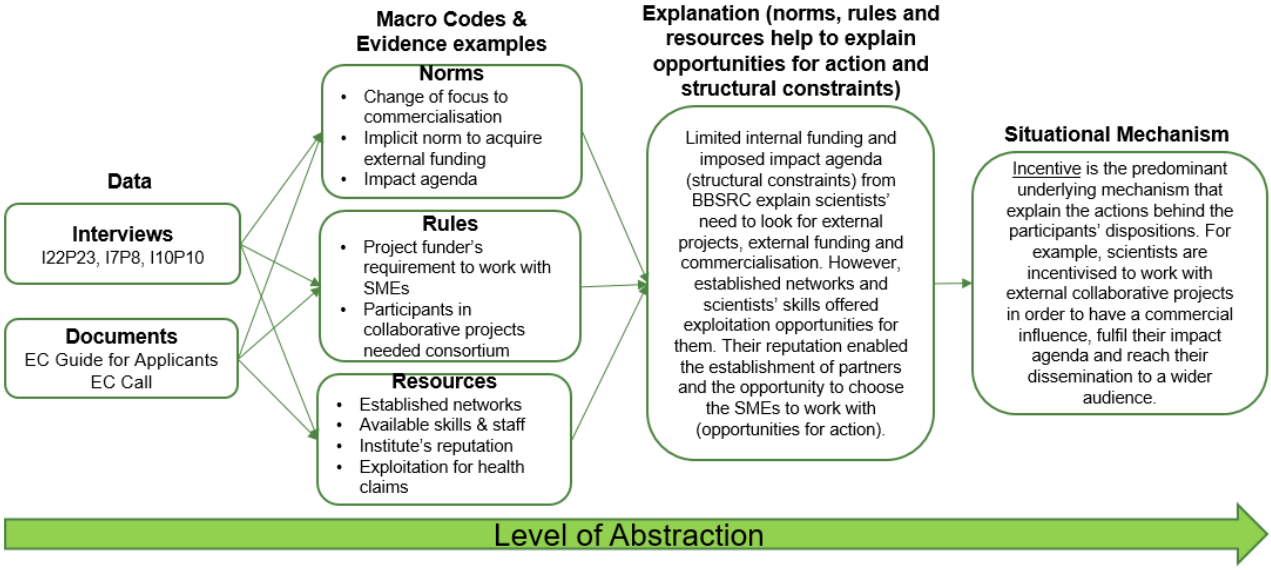
These are examples of questions that were used as a basis for the interviews. Nevertheless, these questions were modified to each interviewee and evolved as the rounds moved on and evidence was gathered for each project. The questions to SMEs were also similar and used to understand their interactions and how they are using the knowledge received from IFR.

1. Could you tell me how project X came about? Who else is involved with this project?
2. What are the current support structure available to encourage industry engagement?
3. What was the objectives for building project X?
4. Why did you want to get involved with this project?
5. How did you find industrial partners for this project?
6. How do you interact with other partners and to SMEs to transfer knowledge? How is the information passed down to them?
7. How are decisions taken within the project?
8. Would you say there was anything different in terms of how this project developed compared to other projects that you were involved?

APPENDIX 3: EXAMPLES OF FINDINGS TABLE

Source	Project	Macro code	Quote
I26P23	BACCHUS	Motivation	I can spend 40 years doing polyphenols research in the lab and if it makes no difference to any product in a shelf and a consumer never gets a choice to buy something that is has a health benefit, there's no point.
I7P8	BACCHUS	Motivation	I do have more applied things that I do which is kind of fun because you tend to meet people, it's much more interactive. I enjoy that side of the table so it works quite well.
I28P13	SUSSLE	Motivation	They (food manufacturers) have a problem of getting rid of their waste material. Their aim is to increase their efficiency, reduce waste, reduce energy costs, and this project has done all of those for them.
I25P26	SUSSLE	Motivation	I do still get involved with some purely academic research, but I think the most rewarding stuff that I do is exactly with the people who actually are going to use what I do.
I47P29	NIS	Interactions	We engage and we discuss a lot. The scientists trust my business experience and I trust their scientific knowledge. I presented strategically the issues that I saw with NIS that was only going to be for small businesses.
I43P16	NIS	Interactions	When the project started we had frequent meetings regarding the nature of the business. They were only discussions with the head of Food Databanks and other colleagues to help shape what it would be, and also to put it in a position to get the translational funding in. Gradually it's got more and more independent and then we brought in Mike as business development manager.

APPENDIX 4 - AN EXEMPLAR OF THE ANALYSIS WITH THE INTERVIEWS AND DOCUMENTS



Evidence		Macro Codes
Documents		
EC Guide for Applicants	*"Proposals are expected to have a substantial involvement of SMEs" (EC call KBBE.2012, Guide for Applicants, pg.6).*	**Rules** Project funder's requirement to work with SMEs
EC Call	*EC call requires consortium agreement for collaborative projects between research institutes and SMEs. (EC call KBBE.2012.2.2-01, pg.13).*	**Rules** Participants in collaborative projects needed consortium
Interviews		
I22P23	*"Ten years ago the word impact didn't exist whereas now it's all they talk about and every single project has to have an impact statement, a pathway to impact" (I22P23, pg.8).*	**Norms** Change of focus to commercialisation Impact agenda
I22P23	*"Smaller companies are very difficult to work with; they don't know what they want. It's very labour intensive for very little return. Larger companies are much more aware of what they want and knowledgeable about their needs. But you have to follow the requirements" (I22P23 pg.3).*	**Norms** Expected to work with SMEs
I7P8	*"We get about 170K a year from our core funding (BBSRC) and our external projects are about 800-900K. So a lot more money we get from external but we have to try and map with what we are doing in the core activities" (I7P8, pg.3).*	**Norms** Implicit norm to acquire external funding
I7P8	*"We have put the consortium together from our own contacts with other academic centres that we knew across Europe. They already have networks of SMEs around them. So we have an absolute framework in the project" (I7P8, pg.1).*	**Resources** Established networks Institute's reputation
I10P10	*"We expect to see some exploitation as well. We are hoping that in BACCHUS we will see the take up of what we are doing by more SMEs, so there might be more health claims coming" (I10P10, pg.14).*	**Resources** Exploitation for health claims
I22P23	*"I work with polyphenols, which is one class of bioactives…I knew a number of people I could bring into the project…Paul F. also spoke about a number of people he could bring in. Although there are several hundred publications, there is only one health claim, none for peptides" (I22P23, pg.1).*	**Resources** Established networks