Assessing Early-Stage Research Results: An Application of Characteristics of Innovation Frameworks

By

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Abstract

The aim of this study is to identify characteristics that can be used to assess early-stage research results by research users and research producers of the advanced biofuel sector. Mainly, it qualitatively explores the perceptions of both research users and research producers regarding their experiences with research results. The study builds on the models of Diffusion of Innovation (DoI), Technology Acceptance Model (TAM) and Perceived Characteristics of Innovation (PCI).

The findings of this study suggest that the investigated dimensions of DoI, PCI and TAM are applicable to the context of assessing research results with the extra dimension of risk reduction. In particular**,** some of the criteria used to assess the usefulness of research results are through its originality, scalability and relevance. The findings also suggest that documentation and publication are important to research users: Research users assess ease of use based on the presentation of the research results in their documentation; and they assess the quality of research results based on publications and the reputation of researchers.

The findings of this study can be used to tailor research results to research users' needs, which in turn can be expected to improve the uptake and further development of research results. This will not only permit the push of scientific research results to research users only put also permit research users to inform research needs.

Dedication

I dedicate this thesis

To my beloved mother,

Fatimah Shiknoor

whose endless support, unconditional love, encouragement and consistent prays on a daily bases gave me the determination and tenacity to achieve such success.

To the memory of my beloved father,

Abdulqader Alhassan

Who would have been delighted to see me thrive at this level of success.

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Chapter 1: Introduction

1.1 Research Motivation

One of the essential elements of any collaboration between university and industry is knowledge and technology transfer. This knowledge transfer assists research users to overcome the challenges that their organizations are encountering or to further improve their performance (Perkmann, Neely, & Walsh, 2011). Therefore, the output of research is significant for research users to meet their needs (Phillipson, Lowe, Proctor, & Ruto, 2012). These needs include problem solving, diffusion of new ideas and addressing policy problems (Crosswaite & Curtice, 1994). The needs of research users vary across the industry due to the type of the user utilizing the research output. They include commercial partners, other researchers, policy makers, regulators, investors, funders, industries, stakeholder and individuals (Jolibert & Wesselink, 2012).

These groups of research users differ widely in their intended use of research results as they determine it based on the level of prior knowledge on relevant topics, and the time and funds they have available to find and access research results. Differences in the way research users interpret research results generate some obstacles for them, which may include—for example—if their particular need cannot be fulfilled easily because available resources were intended for another group with different requirements. Research user groups also have diverse and potentially contradictory values and cultures, and therefore different aims and decision-making processes (Johnson et al., 2013).

The diversity of needs among research users highlights the importance of involving research users in research projects. Active involvement by research users means they have

brought input (e.g., material, knowledge, opinion, financial) at one or more stages of the research process (e.g., research proposal, design, planning) (Jolibert & Wesselink, 2012). Interaction between researchers and research users is a complex, multidirectional process that involves knowledge transfer not only from the researcher to the user, but from the user back to the researcher as well (Ward, House, & Hamer, 2009). Useful knowledge transfer involves interaction between researchers and decision makers; this interaction results in mutual learning that benefits all participants through planning, disseminating, producing and applying new or existing research (Campbell, 2010).

Universities play a leading role in enhancing the development of science and technology. It is widely recognized that the commercialization of university inventions into the marketplace plays a central role in enhancing economic growth, technical innovation and industrial technologies (Payumo et al., 2012; Phan & Siegel, 2006; Pries & Guild, 2011; Donald S. Siegel, Waldman, Atwater, & Link, 2003; Donald S Siegel, Waldman, Atwater, & Link, 2004). Moreover, universities are considered as key actors in knowledge-based economies in which they are expected to have an effective role in stimulating innovation and technological change. In addition to their traditional role in producing commercializable knowledge and qualified researchers, they generate different mechanisms of knowledge transfer, for example, by generating and introducing talent to the economy and cooperating with local industry by providing informal and formal technical support (Bramwell & Wolfe, 2008).

Collaboration between university and industry has accelerated the commercialization of research activity. For example, organizations in the biofuel industry use research results to facilitate the development of biofuels—for various of reasons such as bringing the next

generation of biofuels to market. These organizations ask researchers for different types of information to direct their decision making, to meet a range of other requirements they need and to achieve their objectives. Such co-operation is also necessary in creating new government and business policies related to the biofuel field. Ample evidence has shown that scientific research done in universities has made a significant contribution to this industry, including improving its R&D productivity (De Fuentes & Dutrénit, 2012; Roessner, Bond, Okubo, & Planting, 2013).

Investigation of academics' engagement with external stakeholders has, so far, largely focused on organizational, individual and institutional factors, as well as scientific outputs such as productivity and development of research agendas, and educational and commercial outputs (Perkmann et al., 2013). These perspectives tend to ignore factors related to different characteristics of research results. In addition, such studies typically do not acknowledge the effect on public policy and regulation, which can be critically important to commercial success in applying research outputs, and to the continuation of research practice.

Research activities play an important role in the collaboration process between university and industry, where this collaboration may consist of knowledge, documentation and early-stage research prototypes, which are principal gains of university–industry relations. The literature lacks definite empirical results regarding the nature of knowledge that would help predict the acceptance of research results by potential users. In the context of adopting product or services, many frameworks have been developed to assist the adoption rate of products or services by consumer such as the Diffusion of Innovation (DoI; (Rogers, 2003), the Technology Adoption Model (TAM; (Davis, 1989), and the Perceived

Characteristics of Innovation (PCI; (Moore & Benbasat, 1991). However, such tools, in term of assessing research results, do not exist in the literature of early-stage of university research results. Therefore, it appears realistic to presume that parallel perceptions of DoI, PCI and TAM can be established in the perspective of assessing research results.

According to Rogers (2003), different characteristics of innovation used to assess individuals' perceptions to adopt an innovation are articulated differently depending on whether these attributes are conceptualized in the context of the study under investigation. Therefore, Rogers argues that the measures of these different characteristics of innovation should be exclusively formed in each study. These different characteristics of innovation have been formed within different set of studies such as health care, information technology, and e-commerce, where in each of these fields, these different characteristics have been used to fulfill the purpose of their studies. In this study, we are attempting to determine whether these different characteristics could be formed similarly in the context of advanced biofuels research results.

This study seeks to explore the specific characteristics used to assess early-stage research results that are useful for advanced biofuels research users. Mainly, it provides a qualitative exploration and investigates the perceptions of both research producers and research users with regards to their experiences with the research findings. The study is exploratory in nature and its main purpose is to investigate how research producers and research users of advanced biofuels research perceive the specific characteristics of advanced biofuels research results. Thus, the objective of this study is to obtain deeper understanding of conceptualizations of advanced biofuels research results by research producers and

research users, with the aim of establishing similar scales to DoI, PCI and TAM in the context of advanced biofuels research results.

1.2 Research Questions

A large body of the literature has focused on university–industry engagement. Some of these studies have focused on the university side (e.g., researchers) (Arvanitis, Kubli, & Woerter, 2008; D'Este & Patel, 2007; Welsh, Glenna, Lacy, & Biscotti, 2008) whereas others have focused on the industry side (e.g., research users) (Baba, Shichijo, & Sedita, 2009; Bramwell & Wolfe, 2008; Cohen, Nelson, & Walsh, 2002). A small number of studies focused on both sides of university–industry interactions (Bekkers & Bodas Freitas, 2008; Lam, 2007; Siegel et al., 2003). Many studies emphasize the importance of user involvement in the research process (Driessen & Hillebrand, 2013; Johnson et al., 2013; Jolibert & Wesselink, 2012; Mackinson, Wilson, Galiay, & Deas, 2011; Phillipson et al., 2012; Roelofsen, Boon, Kloet, & Broerse, 2011). Additionally, several studies emphasized the significance of support from the government to enhance the relationship between universities and industries (Bodas Freitas & Marques, 2013; Cosh & Hughes, 2010; Gonzalez-Brambila & Veloso, 2007), which results in facilitating the acceptance of new knowledge.

As it can be seen, there is a large body of literature exists on university–industry collaboration and the assessment of commercialized research results, however, in the context of early-stage research results, assessment has not yet been explored. On the other hand, in contexts other than research results, several scales have been developed. For instance, in product development, several frameworks; such as DOI, PCI, and the TAM; were developed to assess products' uptake by end-users depending on the characteristics of the product while still in the development stage before it reaches the commercialization phase.

In this study, it aims to identify the specific characteristics of early-stage research results that render such results useful for research users in the context of advanced biofuels research. In this sense, the study asks the following questions:

1) What characteristics make research results useful for biofuel research users in order to articulate their needs?

2) Can DoI, TAM and PCI frameworks be applied in the context of early-stage research results?

3) Do these models adequately cover all the dimensions of early-stage research?

1.3 Structure of the Thesis

This thesis contains seven chapters. A brief summary of each chapter is presented as follow.

Chapter 1 presents an introduction that develops the direction of this study. It underlines the research problem, forms the research questions, the objective of the study.

Chapter 2 reviews the relevant literature. It highlights several areas of research, including technology transfer and its mechanisms, multiple stakeholders and type of research users, technology adoption frameworks and the theoretical framework used in this study.

Chapter 3 describes the methodology used to achieve the aim of the study including: the research design, the research method, case selection, data collection and data analysis methods.

Chapter 4 describes the first part of data analysis and results of the semi-structured interview. It presents the finding of the open-ended and structured questions on the uses of research results and the access mechanisms of research results.

Chapter 5 describes the second part of data analysis and results of the semi-structured interview. It presents the findings of the open-ended question of the usefulness of research results and the structured questions that are derived from the DOI, PCI and TAM of the assessment criteria of research results.

Chapter 6 discusses the results of the interviews and presents the ultimate research findings.

Chapter 7 offers conclusions with regards to the findings based on the research questions, the contribution to the literature and its implications for research users and research producers. Finally, it presents the limitation of the current study and recommendations for future work.

Chapter 2: Literature Review

This chapter presents the existing literature by reviewing its relevance to the current study objective as presented in chapter 1. To begin with, the following subsection draws on technology transfer and its mechanisms which present the transfer of university research inventions from researcher producers to research users. This is followed with a review of multiple stakeholders and different types of research users as they play central role of using research results. Followed this an overview of the technology adoption frameworks: DoI, PCI and TAM. This study interprets insights from these streams of research to develop an effective framework that can assist to reach the aim of the study. Subsequently, a review of the link between technology transfer and diffusion of innovation is presented. Lastly, presentation of the theoretical framework that the study is built on will be shown.

2.1 Technology Transfer

The acceleration of technological changes requires knowledge and technology raised from university to be transferred from university to industry which is of great interest to academics, industrial leaders and policymakers. The contribution of university research into new knowledge and technology has significant impacts on the economy, mainly by increasing the productivity of applied industrial R&D, providing a highly qualified workforce, developing tools used in industry, and enabling the generation of new products (Roessner et al., 2013).

According to Audretsch, Lehmann, Link, and Starnecker (2012), technology transfer is the process by which knowledge, inventions, products and scientific findings are

disseminated between universities, governments, the private sector and other parties. Knowledge and technology transfer between academic institutions and business is defined as any activity pointed at transferring knowledge or technologies that may help either the company or the academic institute to improve its performance (Arvanitis et al., 2008). This definition refers to the importance of research users' implementation of the transferred knowledge of technologies for research users' intended needs; therefore, it is appropriate in the context of this study.

Research users engage with universities to transform academic knowledge into beneficial inventions. This transformation enhances a closer linkage with knowledge users (Muscio, Quaglione, & Vallanti, 2013; Perkmann et al., 2013; Subramanian, Lim, & Soh, 2013) that allows them to access scientific knowledge, leverage their R&D and solve their problems (Perkmann et al., 2011).

There is an extensive body of literature on technology transfer, mostly concentrated on technology transfer offices (Comacchio, Bonesso, & Pizzi, 2012; Muscio, 2010), technology transfer mechanisms (Link, Siegel, & Bozeman, 2007; Perkmann & Walsh, 2007), government funding (Muscio et al., 2013) and the characteristics of individuals (Perkmann et al., 2013). Furthermore, a substantial body of literature has focused on measuring the outcome of university research through publications, licenses and startups (Dechenaux, Goldfarb, Shane, & Thursby, 2008; González-Pernía, Kuechle, & Peña-Legazkue, 2013; Henderson, Jaffe, & Trajtenberg, 1998). Other studies have investigated the impact of university research on innovation, although assessing its impact is still a difficult challenge (Nelson, 2012). A summary of these studies can be found in Appendix A.

This literature focused on several issues related to transferring university inventions and technologies between university and industry. One of the main issues that have been well covered in the literature of technology transfer is the assessment of the research output through several tools such as patents, publications, start-ups and licensing. However, these assessment criteria were considered for commercialized research results, leaving the non-commercialized research results that are still in the early-stage development unexplored, ignored or neglected.

Technology transfer can be accomplished through different mechanisms, which can be formal or informal. Formal mechanisms of technology transfer are processed through technology transfer offices, science parks and industry–university research centers, where the main focus is to allocate property rights (Link et al., 2007; Phan & Siegel, 2006). Formal technology transfer mechanisms rely mainly on allocation of property rights through different forms such as patents, copyright and trademarks, which provide protection for research outputs. There are major advantages of this transfer mechanism such as facilitating transfer of research results, establishing strong collaboration with industry, generating funds for further research projects and increasing the quality of research (Payumo et al., 2012).

Informal technology transfer is the facilitation of technology transfer using informal processes that may take different forms (Link et al., 2007). Informal activities include networking, conference presentations, joint publications and informal meetings, whereas formal activities include collaborative research, contract research and consulting (D'Este & Patel, 2007). The main focus of informal technology transfer is on the interaction between university researchers and industry individuals, where the allocation of property rights is a secondary motive (Grimpe & Fier, 2010).

Link et al. (2007) relate the selection of the informal channels to different variables illustrating the characteristics of faculty, including gender, tenure/years with tenure, age and the percent of time spent on grants-related research. Their study found that age has no effect on the engagement in informal activities, but that gender, tenure status, tenured years and time spent on grants-related research have a positive impact on researchers' engagement in the informal forms of technology transfer activities (Link et al., 2007).

These technology transfer activities are considered as pathways in which stakeholders can interact with the transferred technology. The actions of stakeholders represent one of the successful tools for transferring technologies. Their involvement accelerates the flow of knowledge between different stakeholders, which increases the speed of technology transfer.

Technology transfer plays a vital role in bringing discoveries from university to potential users. Therefore, effective technology transfer relies on the ability of researchers to provide research users with knowledge that is desired and facilitate the implementation of it. This cannot be achieved without considering the perception of research users in term of their technological needs.

2.2 Multiple Stakeholders and Types of Research Users

Research users are non-research actors known as stakeholders who are influenced by or benefitting from scientific research directly or indirectly (Jolibert & Wesselink, 2012). They are receivers of the transferred knowledge and technologies that are generated from research activities where they use these generated knowledge for their intended purposes. There are different type of stakeholders which include commercial partner, policy makers, industrial, funders, non-governmental organizations, inventors and individuals.

Involving stakeholders in research projects can result in the development of products that efficiently assist in solving complex societal problems and increase the scientific and societal value of research (Roelofsen et al., 2011). The involvement of stakeholders can take different forms depending on research needs and purpose. The level of this involvement is specified by the type of issue and the contribution that they can make, as a result, to enhance the communication effectiveness in promoting problem solving, effective participation of stakeholders and evaluation of the outcome of the stakeholders participation (Mackinson et al., 2011).

Phillipson et al. (2012) propose that stakeholders' participation in environmental research can lead to greater understanding of the way knowledge is produced and applied in environmental research and management. Garnett et al. (2009) suggest that the role of different stakeholder groups as co-researchers can shed light on the importance of stakeholder's involvement in the forming of the research questions from the onset. The importance of these different stakeholder groups varies across industry fields, but it is particularly important when complex environmental concerns may arise (Phillipson et al., 2012).

Previous studies suggest that stakeholders are an important factor that cannot be ignored in new product development (NPD) (Baron, 2006; Driessen & Hillebrand, 2013). In addition, other studies show the importance of integrating stakeholder concerns in management decisions and its positive consequences on financial performance (Orlitzky, Schmidt, & Rynes, 2003). In the field of NPD, it has been demonstrated that organizations that take into consideration different stakeholders opinions in their NPD decisions show better performance (Talke & Hultink, 2010).

One framework that has been applied in the literature is the differentiation between stakeholders based on power, legitimacy and urgency provide by Mitchell, Agle, and Wood (1997). This framework has also been successfully applied to the NDP context, for example through Quality Function Deployment (Yu, Chen, Chen, & Chang, 2012).

Research on different industries shows that the interaction among a variety of users is necessary for both generating and transferring knowledge (Adams, Fontana, & Malerba, 2013). These users differ within an industry; they can be groups, research organization, universities, institutions or societies. These users roles and their impact on innovation differ based on which sector they are involved in (Adams et al., 2013; Mitchell et al., 1997). Many research institutions encourage the participation of users in research due to their importance for knowledge transfer as a mechanism for exploiting research results (Phillipson et al., 2012).

Engaging stakeholders in knowledge production have been shown to be beneficial to this process (Phillipson et al., 2012) as they play an important role in scientific systems (Maclean, Anderson, & Martin, 1998). Maclean et al. (1998) have shown that the characterizations of different groups of users and the description of value-added chains from researchers to end users map science outputs to user needs and assist in identifying common interests in a relatively objective manner. They classified users into different categories such as users with long-term needs versus short-term needs, users with specific needs versus generic needs, proactive users versus reactive users, and end users compared with intermediate users. This classification helped balance the visions of a full range of different types of users. It also enabled users to define the suitable mechanisms of communication with different users.

2.3 Technology Adoption Frameworks

There is substantial work on the frameworks of users' adoption of technology, products or services. Three streams have developed from this research (Gounaris & Koritos, 2008): DoI (Rogers, 1962), TAM (Davis 1989), and PCI (Moore & Benbasat, 1991). These three frameworks on the adoption and diffusion of information technology have gained increasing attention in the literature (Gounaris & Koritos, 2008). Despite differences between these frameworks, a common theme of discussion underlying the several streams of research on technology adoption is the presence of perceptions of an innovation as an important characteristic (Agarwal & Prasad, 1997). New ideas represent innovation for users where their perception of individuals as users is assumed to be vital which have an effect on user's behavior of acceptance. These frameworks were applied within IT fields, however, they tend to focus on the behavior of the users in order to reject or accept an innovation. In this sense, it seems reasonable to anticipate that these models can apply to the present context. The frameworks will be described in the following subsections.

2.3.1 Diffusion of Innovation (DoI)

The diffusion of innovation framework has been widely applied within several disciplines such as information technology, education, healthcare, communication, marketing and agriculture. This framework is a knowledge area based on Rogers (1962). It illustrates the diffusion of new ideas through different channels by reaching users and providing them with alternatives in order to solve their problems (Rogers, 2003). According to Rogers, diffusion is defined as "the process in which an innovation is communicated through certain channels over time among the members of a social system" (2003, p.5). Diffusion is considered as a unique type of communication that deals with the spread of messages that

may appear as new ideas to the users. This definition distinguishes four main elements in the diffusion of innovation process: innovation, communication, time and social system.

An innovation is identified as any idea or practice that is considered as new by adopters (Rogers, 2010). It is perceived that a new idea is an innovation when individuals perceive it as new and it is articulated in term of knowledge or the decision to adopt. Rogers (2003) distinguishes new ideas as technological innovation where he identifies the term of technology as not only software and hardware. His definition of technology implies that information or knowledge results from scientific R&D activities, therefore, technological innovation is identified by Rogers (2003) as "a means of uncertainty reduction that is made possible by information about cause-effect relationships on which the technology is based" (p.13).

The framework proposes that, when new innovations are presented to users, users will perceive some level of uncertainty when deciding whether or not to adopt the innovation. Given this uncertainty, they will seek information to assess different characteristics of the innovation to decide whether or not to adopt it. The framework demonstrates the innovation-decision process path in which an individual passes through when experiencing new innovations or ideas. The process starts from obtaining initial knowledge about the innovation, to forming an attitude toward it, to deciding to adopt or reject, to implementing the new idea, and finally to confirming the decision made (Rogers, 1995).

The theory provides five characteristics that influence the perception of adoption or rejection of an innovation by end users. These characteristics of innovation include relative advantage, compatibility, complexity, trialability and observability. These perceived characteristics assist in describing adopters' perception rates of innovation. Relative

advantage is defined as the degree to which an innovation is perceived to be better than another. An individual is more likely to adopt an innovation as long as they are aware of the benefits of adopting it. Compatibility is the degree to which an innovation is perceived to be consistent with existing values, past experiences and needs. Complexity is the degree to which an innovation is perceived to be difficult to understand and use. Trialability is the degree to which an innovation can be experimented with on a limited basis. Observability is the visibility of the adoption results to others.

The essential process of diffusion is to exchange information, at least between two parties of individuals that involve innovation and individuals through communication channels. Therefore, Rogers identified the second element of a diffusion "communication channel" as a path for information to be exchanged from one individual to another (Rogers, 2010). The theory identified communication as the process of exchanging information between individuals to achieve common understanding.

The third element in the diffusion process is time, which is an important dimension of the process of innovation diffusion and adoption. Rogers indicates that time is involved in the diffusion process in three ways: the innovation decision process, the innovativeness of the individual, and an innovation rate of adoption in the system. The innovation decision process is the process by which an individual proceeds through the different stages of an innovation decision. These stages include (1) knowledge about the innovation, (2) persuasion, (3) decision, (4) implementation and (5) confirmation. The innovativeness of the individual refers to the phase in which the adopter is going to adopt the new ideas earlier than other individuals within a social system. Rogers classified adopters into five categories including innovators, early adopters, early majority, late majority and laggards. The innovation rate of

adoption refers to the rate in which an innovation is adopted within a social system. As mentioned earlier in this section, the rate of adopting an innovation is influenced by the five characteristics of innovation (Rogers, 2010).

The social system, the fourth element, is defined as a set of several units that are involved to solve a problem in order to achieve a goal (Rogers, 2010). The units in a social system may involve individuals, groups, organizations and subsystems, where each unit can be distinguished from the other units in term of their goals and objectives. The different members of the social system are expected to collaborate to the extent that they can solve or inform a common issue in order to reach a mutual objective (Rogers, 2010).

2.3.2 Perceived Characteristics of Innovation (PCI)

The characteristics of innovation were developed and modified by Moore and Benbasat (1991). They developed the Perceived Characteristics of Innovation (PCI) model based on Roger's DoI framework. The PCI framework focuses on measuring the perceptions of individuals with regards to the use of an innovation, instead of measuring the innovation by itself. Therefore, Moore and Benbasat reidentified Rogers' characteristics of innovation by adding two more characteristics to the original five. The two additional characteristics were identified to be essential in the adoption of innovation. The first concept is voluntariness, which is identified by Moore and Benbasat (1991) as "the degree to which use of innovation is perceived as being voluntary, or of free will". The second concept is image, which is defined as "the degree to which use of an innovation is perceived to enhance one's image or status in one's social system". This framework have been widely used in several dicipline as it is showen in Table 1.

Table 1 PCI Examples

Field	Studies	Focus
Information Technology	(Cruz, Neto, Muñoz-Gallego, & Laukkanen, 2010)	Perceived obstacles to the adoption of mobile banking services among Brazilian internet users
	(D. A. Adams, Nelson, & Todd, 1992; Perez, 2013)	Factors influencing adoption of information systems in the medical education sector
E-commerce	(Poong, Eze, & Talha, 2009)	A framework to explain business-to-consumer e-commerce adoption among Malaysian consumers
	(Andrews & Bianchi, 2013)	Factors that influence the purchasing behavior of Internet consumers
E-government	(Rokhman, 2011)	Acceptance of Indonesian Internet users to e-government services in terms of relative advantage, image, compatibility and ease of use variables
	(Hussein, Mohamed, Ahlan, & Mahmud, 2011)	Factors influencing the intentions of citizens to use e-filing in the Malaysian context.
	(Carter & Belanger, 2004)	Factors that influence citizen adoption of e-government initiatives

Source: Author's presentation

2.3.3 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) is a theoretical framework developed by Davis (1989), which builds on the Theory of Reasoned Action (TRA) (Fishbein & Ajzen, 1975). The TAM is a very commonly used theory in information systems to explain the behavior of user acceptance. This model has been replicated through different studies within several disciplines (Davis & Venkatesh, 1996) such as healthcare (Holden & Karsh, 2010), e-government (Lin, Fofanah, & Liang, 2011) and education (Schoonenboom, 2014). The Technology Acceptance Model aims to produce measurements that effectively predict the use of technology systems (Davis, 1989). It addresses the causes of user acceptance or rejection of information systems and how system design features affect their acceptance of information systems.

The proposition of TAM relies on the user's motivations for using a system, which would be influenced by three main factors: perceived ease of use, perceived usefulness, and attitude toward using a system. The attitude toward using a system is a main factor in an individual's decision to adopt or reject a system. This factor is considered to be affected by two main beliefs: perceived ease of use and perceived usefulness, where perceived ease of use has a direct influence on perceived usefulness. These two factors are directly affected by system design features that indirectly influence attitudes toward using a system (Davis, 1993).

Davis (1989) theorized two key indicators for a user's acceptance of new technology: the perception of ease of use and the perception of usefulness. Empirical studies found that the two concepts have an effect on each other, where perceived ease of use has an effect on perceived usefulness, indicating that the usefulness of the system depends on its simplicity to use (Davis, 1989; Davis, Bagozzi, & Warshaw, 1989). For example, previous studies employed TAM theory to investigate the adoption of e-government services by business users (Lee, Kim, & Ahn, 2011) and developed a model in an educational setting for university student acceptance of mobile learning (S. Y. Park, Nam, & Cha, 2012). Table 2 presents a summary of empirical studies of TAM.

The development of the TAM is constructed on information system acceptance, which was implemented in different areas. However, it was not applied to (or implemented for) university research results. Therefore, this study proposes to develop a similar scale to the context of research results. It uses the TAM factors to explore the perception of research producers and research users to assess research results.

Table 2 TAM Examples

Field	Studies	Focus
IT	(Gefen & Straub, 1997)	Effect of gender on IT diffusion
	(Mah, Hissan, & Ch'ng, 2011)	Acceptance of Mobile Curriculum Vitae (m-CV)
Healthcare	(Holden & Karsh, 2010)	Applicability of the TAM for healthcare
	(Gagnon, Orruño, Asua, Abdeljelil, & Emparanza, 2012)	Acceptance of a telemonitoring system by healthcare professionals
	(Kowitlawakul, 2011)	Factors that influence nurses' intention to use the Electronic Intensive Care Unit (eICU) technology
E-Commerce	(Johar & Awalluddin, 2011)	Aspects that influence and contribute to the customers' intention to use e-commerce
E-Government	(Shyu & Huang, 2011)	Factors influencing e-government learning and the acceptance of web-based technologies
	(Shareef, Kumar, Kumar, & Dwivedi, 2011)	Critical factors influencing the adoption of e-government at different stages of service maturity
	(Lee et al., 2011)	Adoption of an online tax filing service by business users
Education	(Schoonenboom, 2014)	Explanation of different tools used within Learning Management Systems (LMSs) by instructors in higher education
	(Edmunds, Thorpe, & Conole, 2012)	Technology acceptance through a comparison of work, study and leisure contexts
	(S. Y. Park et al., 2012)	Mobile learning acceptance of university students
	(Cheng, Lou, Kuo, & Shih, 2013)	Acceptance of technology by applying digital game-based learning to environmental education
Product Adoption	(Broman Toft, Schuitema, & Thøgersen, 2014)	Smart grid technology
	(E. Park, Kim, & Ohm, 2014)	Adoption of car navigation systems

Source: Author's presentation

2.3.4 The Use of Technology Adoption Frameworks

These frameworks mainly focus on understanding the conceptualization of end user perceptions when accepting or adopting innovations. The main actor in these frameworks is the end user, where the end user believes and intends to use an innovation and is influenced

by the characteristics of the innovation. These innovations vary across a social system ranging from new ideas to products and services within a social system. They have been applied to variety of research areas such as healthcare, e-commerce, education, IT, e-government, and others, as was shown in the previous sections. However, in the context of early-stage research, such frameworks do not exist. Therefore, in this study, we employ the characteristics of innovation from DoI, TAM and PCI to assess whether they would be applicable in the context of research results. The application of these models is assumed to give a comprehensive explanation of research users' intention to use research results.

As mentioned earlier, Rogers (2003) defines diffusion of innovation as "the process in which an innovation is communicated through certain channels over time among the members of a social system". The four main elements of the diffusion of innovation are considered in the context of this study as follows. By adopting Rogers (2003) definition of innovation, research results will be an innovation, which are inventions resulting from research activities and perceived as new to research users. The communication channels are considered as channels for accessing research results such as publication and direct communication with researchers and conferences, in the context of this study the focus is not on these channels, however, the contribution of these channels might influence the assessment of research results. The time that research results might take to be transferred, adopted by potential users and implemented may have an influence on the research users. It can influence the decision to apply the research results and the rate of implementation. The social system within the context of this study involves two parties of individuals including research producers who produce research results and research users (stakeholders) who use research results and who collaborate in order to reach a specific goal.

2.4 Technology Transfer and Diffusion of Innovation

Rogers (2003) referred to technology as not only software or hardware, but also as information resulting from scientific R&D activities in order to achieve certain organizational goals. Transfer is referred to as the movement of a technology from one party to another. Technology transfer, as identified earlier, is the process in which scientific inventions are communicated through different mechanisms in order to be put into use. Scientists are considered to be the producers of these inventions; they are the source of information about technological innovation that is associated with users in another organization. These users may commercialize these inventions into products or services (Rogers, 2002). Technology transfer is not the process of transferring technology to another party only; instead, it is a continuing process to ensure future engagement. (Cottrill, Rogers, & Mills, 1989) offered a brief description of technology transfer and diffusion of innovation streams. They explained that both streams are concentrating on causes of social change, however, the process and structure streams are different. Table 3 presents the differences and similarities in both the streams.

Rogers (2002) explained that the effectiveness of technology transfer does not depend only on the effectiveness of the R&D organization (e.g. a university) but also on the way the receiver of this knowledge (e.g. a research user) acts in adopting and implementing the technology.

Table 3 Similarities and Differences between Technology Transfer and Diffusion of Innovation

	Technology Transfer	Diffusion of Innovation
Definition	The process in which a scientific invention is communicated through different mechanisms in order to be put into use.	The process in which an innovation is communicated through certain channels over time among the units in a social system
	Technology: Information that is put into use to complete some tasks	Innovation: an idea perceived as new
	Transfer: the communication process	Diffusion: the communication process
Orientation	Scientific producers (researchers)	Individual users
Focus	Technology utilization and implementation for users	
Emphasis	R&D organizations (Mainly universities) as producers	Individuals as adopters
Nature	Planned and designed	Occurs as a result of innovation generation
Focus process	Research result: commercialization	Technology adoption

Source: (Cottrill et al., 1989)

2.5 Theoretical Framework

As a framework, this study employs theoretical frameworks that build on the diffusion of innovation literature. They include DoI (Rogers, 2003) , TAM (Davis, 1989) and PCI (Moore & Benbasat, 1991). TAM is a widely accepted model that is based on social psychology theory and has empirical support from various studies. PCI also has been used in studies of information system adoption and to analyze the perceptions of users in term of adoption. In the context of research results, several assessment methods apply; however, these methods assess commercialized research results. This study employs these theoretical frameworks in order to build a framework that assesses early-stage research results to meet research users' needs.

This study employs the DoI framework along with TAM and PCI to identify the specific characteristics that assess advanced biofuels research results. These theoretical frameworks identified several constructs as were mentioned earlier in this chapter. The study

uses six characteristics from these models and add an extra dimension, as will be presented in the following section. These characteristics were chosen based on the author's judgment with regards to their applicability to the context of research results.

1. Usefulness is the degree in which research results captures research users' perceptions regarding the benefits that they will obtain from adopting research results. A considerable number of studies have indicated that perceived usefulness is a significant indicator of behavioral intention to use and adopt technology (Davis et al., 1989; Venkatesh, 2000; Venkatesh & Davis, 2000). These studies provided support for Davis et al. (1989), who argued that, within the real work environment, behavioral intentions depend mainly on performance-related elements, instead of the attitude of individual's towards the behavior. In the context of this study, usefulness captures the perceptions of research users regarding how they measure the benefits that they will obtain from adopting research results. In other word, how they assess the usefulness of research results.

2. Ease of use is the degree to which a research result is perceived as being easy to use. Several studies implied that perceived ease of use influences intention of perceived usefulness directly and indirectly (Agarwal & Prasad, 1997; Davis et al., 1989; Venkatesh, 1999; Venkatesh & Davis, 2000). The direct form implies that perceived ease of use influences user acceptance of a system. The indirect form suggests that, when the system is easy to use, it facilitates other tasks of the system to be achieved compared to when it is the system is hard to use (Venkatesh & Morris, 2000). In the context of research results, ease of use captures the degree to which a research result is perceived as being easy to use, and this study would like to investigate how research users conceptualize the ease of use of research

results. In other words, how would research users measure the ease of use of research results in order to reach their ultimate desire of using research results.

3. Relative advantage is the degree in which research users perceive that a research result is better than other research results. Relative advantage refers to the ability of the technology or an innovation to reduce cost, save time, decrease discomfort or enhance economic factors. The nature of the innovation regulates what particular type of relative advantage is essential to the adopter, even though the characteristics of the potential adaptors could influence which sub-dimensions of relative advantage are the most significant (Rogers, 2010). Numerous studies stated that relative advantage is one of the main indicators of the adopters' decision to adopt a technology (Kolodinsky & Hogarth, 2001; Polatoglu & Ekin, 2001; Tan & Teo, 2000). In the context of this study, the factors that influence a research user's relative advantage of using research results are being investigated.

4. Compatibility is the degree to which an innovation is perceived to be consistent with existing values, past experiences and needs (Rogers, 2010). This characteristic is attained when a new innovation, technology or idea is clear to adopters and meets their central needs in comparison with their previous experience. Several studies found that this characteristic has a positive influence on an adopter's intention (Agarwal & Prasad, 1997; Kolodinsky & Hogarth, 2001; Tan & Teo, 2000). In term of this study, it investigates the aspects that influence, or measure, the compatibility of research results.

5. Status is the degree to which research results captures the perception that using research results will contribute to enhancing the social status of research users. Rogers (2003) stated that status affects the acceptance and use of an innovation. It refers to research users' perceptions that adopting research results makes them superior to others in the society.

Interaction with university researchers and using research results is perceived to give research users superior status. Many researchers have included this dimension in their proposed model in innovation adoption (Carter & Belanger, 2004; Kulviwat, Bruner Ii, & Al-Shuridah, 2009).

6. Quality is an extra dimension that assess the degree to which research results capture the perception of research users on how they conceptualize that research results are fit to use and are done correctly.

This study assumes that similar characteristics to these frameworks' characteristics can be established to the context of early-stage research results.

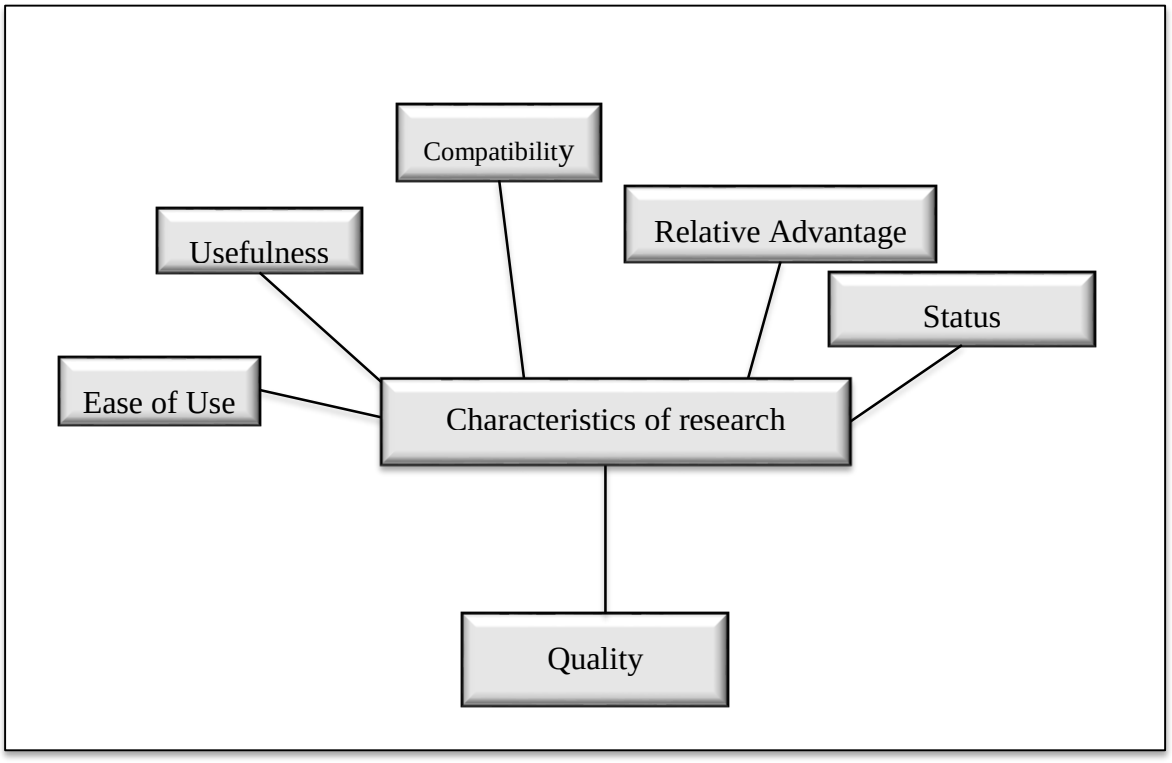

Figure 1 Theoretical framework

Chapter 3: Methodology

The aim of this chapter is to provide an explanation of the research strategy, research design and research method. It describes the purpose of employing the specific research approach. Table 4 provides an overview of this methodology chapter.

Table 4 Methodology Summary

	Steps	Application
Research Approach	Research design	Qualitative case study research method
	Research method	Single case of research users and research producers of second-generation biofuels research
Data Collection	Select research instrument	Semi-structured interviews
	Selection of research respondents	Biofuel research users and research producers
	Place	– World Congress on Industrial Biofuels – The BioFuelNet Annual General Meeting
Data Analysis	Carry out within-case data analysis	– Content analysis of each case – Coding and classifying of the data
	Carry out cross-case data analysis	Comparison of the similarities and differences of the two groups of participants

3.1 Research Design

The qualitative approach focuses on understanding the behavior of individuals and their perceptions of existing concepts that assist to describe human social behavior (Yin, 2010). Furthermore, qualitative methods emphasize understanding, interpretation and observations in natural settings and a closeness to the data (Creswell, 2012). Creswell (2009) states that this approach is explanatory in nature and is a useful tool for researchers to explore new topics that were not addressed before (Morse, 1991).

The selection of the research approach depends on the type of study and research questions that needs to be addressed. Thus, since the nature of this study is exploratory in that it aims to build a framework regarding the useful characteristics of biofuel research results, employing a qualitative research approach with some quantitative description is suitable to accomplish the purpose of this study.

3.2 Research Method

A qualitative case study approach allows the researcher to investigate the phenomena in its context. Therefore, this approach was used to generate a framework following Yin's (2009) guidelines.

The case study research method is frequently employed in many fields, including management studies (Yin, 2009). It is an empirical methodology that explores the studied phenomenon under investigation in depth and within its real-life perspective, particularly when the boundaries between phenomenon and context are not clearly apparent (Yin, 2009). This method can be used in the exploratory stage of a research topic to determine essential features, factors or issues that might apply in other similar situation (Myers, 2013). It is a useful method for investigating new topics not addressed in the literature. The purpose of the case study research method is to use empirical evidence from real people in real organizations to make an original contribution to knowledge (Myers, 2013).

The case study methodology can be implemented using one of two designs: single case or multiple cases. The use of single case studies is appropriate in several situations when testing theory; it enables the researcher to determine whether a theory is suitable to be applied in different settings, and it enables the researcher to distinguish between

complementary sets of justification (Yin, 2009). The single case study design can also be used when building theory; it can help further investigate within the field of the study (Yin, 2009). On the other hand, multiple case studies combine several single cases, and they can be employed for literal replication or theoretical replication Yin (2009).

Single case study involves two designs: holistic and embedded. The design of this type of case study depends on the number of the analysis units within the case. The holistic design is appropriate when the study involves one unit of analysis. On the other hand, the embedded design would be employed if there is more than one unit of analysis (Yin, 2009). Given that the purpose of this study is to identify the characteristics of research results with the use of characteristics of innovation frameworks from the perspectives of research users and research producers, it is appropriate to employ an embedded single-case study design where research users' and research producer' perceptions are analyzed in two separate groups.

To summarize, the main aim of the study is to identify the specific characteristics of research results that cause research producers and research users to perceive early-stage research results in the field of advanced biofuels as useful. The design of this study includes an embedded single case study in field of next-generation biofuels research. Single case design is appropriate because the current study involves one case which is next-generation of biofuel. Embedded design of the case is appropriate as the study is constructed on an empirical analysis of the perception of two groups: research users and research producers. The perceptions of research users were important in order to understand how they would conceptualize the useful research results to provide them with required knowledge. The perceptions of research producers were also important to investigate how they would

conceptualize the characteristics of their research results in term of their usefulness to research users. The level of analysis is the perception of individuals from the research users and research producers groups. The analysis of the individual's perceptions includes within-group and cross-group analysis. Within-group analysis is employed to allow the researcher to explore the perception of each group distinctly. Cross-group analysis of the two groups' perceptions is employed to obtain high level of abstraction between the two groups of participants in order to distinguish any similarities and differences of the participants' responses.

3.3 Case Selection

The next generation of biofuel technologies faces considerable limitations to its commercial implementation. Therefore, there is a need for researchers to provide knowledge that can successfully bring the next generation of biofuels to the market. Considerable research efforts are required in order to assist biofuel stakeholders to enhance the production and commercialization process as well as improve several technical issues related to advanced biofuels. Sims, Mabee, Saddler, and Taylor (2010) outlined that there are several technical development research and policy issues required to be addressed in order to enhance our understanding of feedstock and reduce costs, development of technical aspects such as biochemical routs and the thermo-chemical route, and co-products and process integration. A broad range of stakeholders is engaged to enhance the production of next-generation biofuels, therefore, they need diverse forms of information for decision-making processes (Johnson et al., 2013). Consequently, this sector has proven itself to be a good case study for identifying the characteristics that assess research results. Research and development needed in this sector, where assessing research users' needs of research results

while research is in the development stage assumed to provide useful outcomes for this sector.

3.4 Data Collection

3.4.1 Interviews

Interview as a method of data collection involves three different approaches: structured interviews, unstructured interviews and semi-structured interviews (Myers, 2013). During structured interviews, the researcher uses structured questions that are asked in a particular order within a certain time. By contrast, the questions in the unstructured interviews are not pre-formulated; the researcher asks about different topics relating to the aim of the study (Myers, 2013; Sreejesh, Mohapatra, & Anusree, 2014). The semi-structured interview is positioned in between the other two types of interview. It covers the use of open-ended questions and structured questions, and is one of the most commonly used types in qualitative business research (Myers, 2013) .

The primary sources of data collection in this study are semi-structured interviews. To develop an understanding of the relationship between the research users and the perceptions of research producers, we conducted exploratory semi-structured interviews. This approach was chosen due to its ability to allow researchers to explore the perceptions of the respondents. This type of interview enables the researcher to discuss answers with respondents and ask for more clarification if needed.

3.4.2 Interview Guide Development

The interview guide aims to investigate the perceptions of research users and research producers regarding the usefulness of research results. Research users are asked to reveal their perceptions on assessing useful research results that benefit their own needs. Research producers are asked to describe how their research users conceptualize the usefulness of research results. The interview guide was constructed to determine these perceptions, which involved structured and unstructured questions.

The interview guide of the current study (see Appendix D) involved different sections of questions. The first set of questions (Q#1 and Q#2) aimed to gather general information such as name, experience, type of biofuel and type of feedstock. The second set of questions (Q3 and Q4) involved open-ended questions related to general perceptions of the use and usefulness of research results. This section allowed participants to explain their main uses of research results and list the factors that make the research results useful. Following that, a 7-point Likert-type scale question that identified six purposes of using research results from the literature (Bishop et al., 2011) was employed.

Table 5 Adopted Dimensions from DoI, TAM and PCI

Dimension	Definition	Source
Usefulness	Research users' perceptions regarding the benefits that they will obtain from adopting research results	TAM
Ease of Use	The degree to which a research result is perceived as being easy to use	TAM
Relative Advantage	The degree to which the use of research results are perceived as better than others	PCI
Compatibility	The degree to which the use of a research result is perceived to be consistent with existing technology and the users' need	PCI
Status	The perception that using research results will contribute to enhanced social status of research users	PCI
Quality	Captures the perception in which research results are done correctly	

The third set of questions ($Q\#6_a$ to $Q\#6_f$) involved structured questions derived from the literature on the adoption of innovation. This section includes questions regarding the perceptions of the usefulness of research results assessment measures. The perceptions questions were derived from models widely used in the academic literature such as the Technology Acceptance Model (Davis, 1989), the Perceived Characteristics of Innovation (Moore & Benbasat, 1991) and the consumer adoption literature (Kim, Chan, & Gupta, 2007). These questions included the participants' perceptions on assessment measures of research results such as degree of usefulness, ease of use, relative advantage, compatibility, status and quality. These characteristics are defined in the context of this study as shown in Table 6.

This set of questions was followed with an open-ended question regarding the shortfalls of research results followed by a seven-point Likert-type scale question that assesses the access mechanisms of research results.

3.4.3 Sample

Sampling is a complicated process in qualitative research, which involves many different approaches (Coyne, 1997). It includes deciding about settings, events and social processes, not just deciding who will be involved in the study (Miles, Huberman, & Saldaña, 2013). The selection of the sample in qualitative research has a strong effect on the quality of the research (Coyne, 1997).

Purposive sampling is one of the most used sampling techniques in qualitative research which is based on non-probability sampling techniques. This kind of sampling technique involves several types such as maximum variation sampling, homogeneous sampling, snowball sampling, theoretical sampling and random sampling (Miles et al., 2013; Patton, 2002; Yin, 2010). Deciding on the type of sampling strategy depends on the researcher's judgment in order to fulfill the purpose of the study under investigation (Miles et al., 2013).

The selection criteria of the participants is first and foremost whether they are conducting research on biofuels or using outputs from such research. Research users were identified as industry and policy makers who are using or considering using research results. Their participation gives insight into their needs from research results. The other group of participant – research producers – are expected to identify their perspectives on what makes their research results useful for research users where they play a central role in knowledge production. These different perspectives within both groups give complementary views on

the characteristics that benefit research users. Determining the sample size depends on the purpose of the study, and there is no specific rule to decide the sample size in qualitative research (Patton, 2002). The sample size in qualitative research is usually small to build clear understanding of the data and study it in depth (Miles et al., 2013).

This thesis presents findings from interviews with 22 participants of biofuel research users or biofuel research producers. The interviews were conducted in person at two conferences: the World Congress on Industrial Biotechnology (BIO) and the BioFuelNet Annual General Meeting (BFN). The length of each interview was about 20 to 25 minutes.

The two conferences were selected as they are assumed to bring together most of research users and research producers of the biofuel industry. The data gathered from BIO is expected to be a suitable fit for our sample because this conference brings together business leaders, investors and policy makers in the biofuel industry. The BIO is considered the largest trade association that represents technology companies, academic institutes and related organizations. The members of this association are engaged in the research and development of multidisciplinary and innovative fields such as agricultural, industrial and environmental biotechnology products.

BFN is a research association that brings together Canadian biofuel researchers who address biofuel challenges. The objective of this association is to enhance environmental sustainability for future generations by applying and developing innovative sciences and socio-economic policies. They believe that the growth of a socially, economically and environmentally sustainable advanced Canadian biofuels industry would be driven through

different gateways such as coordinated research, innovation, effective education, smart polices and strategic partnership.

3.4.4 Ethics

As this study involved human subjects, it followed the University of Ottawa ethics procedures. Approval from the ethics review board was obtained (see Appendix B). A letter of information was provided to the participants, along with a consent form to sign (Appendix C). The letter outlined the main aspects regarding to their participation such as objectives of the study, the voluntary nature of their participation in the study and an overview of concerns associated with confidentiality.

3.5 Analysis

The obtained data were entered into a Microsoft Excel file in order to organize them for the subsequent analysis. Even though there are several qualitative computer applications that can assist to analyze data, it was not necessary for this study as the amount of data obtained in this study was not large enough to require such computer applications. Rather, the data were processed using Microsoft Word to code and categorize data; Microsoft Excel was used to obtain percentages as part of the quantitative data analysis for some questions.

The analysis of the data involved primary and secondary analysis methods. The primary method of analysis followed qualitative content analysis for the open-ended questions. The secondary method of analysis involved a simple quantitative analysis of structured questions. These methods of analysis will be described in the following subsections.

3.5.1 Primary Method: Qualitative Content Analysis

Patton (2002) identified content analysis as *"any qualitative data reduction and sense-making effort that takes a volume of qualitative material and attempts to identify the core consistencies and meaning." (p.453).* Content analysis is a research analysis method that is used to interpret data from its context. It provides novel perceptions and enhances the researchers' understanding of specific phenomena (Krippendorff, 2013). Content analysis is a method that concentrates on the content and patterns of the data, allowing justification of the context to avoid researcher bias (Neuendorf, 2002). It is employed to identify the actual meaning of words, concepts, phrases or sentences within the data (Krippendorff, 2013).

Content analysis can be employed as part of either inductive or deductive analyses. The purpose of the study determines which form of content analysis to use. Indicative content analysis is used when there is no previous knowledge about the phenomena under investigation. Deductive content analysis is employed when the construction of the study is based on previous knowledge, and it is used to test theory. As this study is exploratory in nature, and the aim is to develop the specific characteristics that assesses early-stage research results that are not explored yet based on DoI, PCI and TAM, inductive and deductive content analysis are employed. In present thesis, the inductive content analysis was employed to analyze the responses of the open-ended questions. On the other hand, as this study is based on the DoI, PCI and TAM frameworks, the dimensions used from these frameworks employed deductive content analysis where the dimensions were used to identify concepts related to the assessment of research results.

Employing this method of analysis consists of coding and sorting the data into categories that are defined by the researcher or established during the analysis process (Krippendorff, 2013). It is used to examine documents and written materials through a categorization of codes. The codes of a content analysis reflect the overall trends in written material. The identified codes are established through different levels such as sentences, words or themes. The coding for the content analysis is employed by the researcher's assessment of the use of conceptual and relational analysis (Krippendorff, 2013). A category can be identified as a group of words that have related meaning that support the implications drawn by the researcher (Patton, 2002).

Content analysis permits researchers to develop implications from the material to support the aim of the study. The developed interpretation of using content analysis should tackle research questions that were identified in the beginning of the study (Krippendorff, 2013). The researcher plays an essential role in identifying the categories that link the context of the data being analyzed. It is the researcher's responsibility to decide the significance of the developed interpretation of the data depending on the aim of the study (Neuendorf, 2002).

As will be described in the following subsections, the procedure to analyze the data followed three steps: coding and categorizing, data presentation and interpretation, and then drawing implications.

3.5.1.1 Coding

The initial step of data analysis started by reading and coding the data to construct knowledge of the respondents' perceptions. The coding process was inductive in nature,

where the codes were based on the respondents' perceptions. After the codes were identified, they were sorted into categories depending on their meaning to establish patterns of the obtained data. Creswell (2012) advocated for the "use of categorical aggregation to establish themes or patterns". To group the codes, the codes of each question were listed in a Microsoft Word document, allowing the researcher to read over them and cluster the common patterns codes into one category. The categories were put into a table for a clear visualization of the category and the codes within each category. Each question of the questionnaire included a different number of categories. Also, each category within each question included a different number of codes depending on each question.

In order to reduce potential bias of the researcher and enhance the reliability of the data, two researchers conducted the analysis of the data. Neuendorf (2002) suggested that the data needs to be analyzed by at least two individual coders. This process is called an interceding reliability test, which is a widely employed coding technique. There is increased attention in the literature of the importance of establishing inter-coder reliability (Neuendorf, 2002). The reliability of the inter-coder means refers to the degree to which two or more coders achieve a high level of agreement on their coding scheme. There is no standard measure of the inter-coder reliability (ICR) of content analysis, however, it is essential to obtain high ICR when the analysis involve more than one coder (Burla et al., 2008; Elo et al., 2014; Neuendorf, 2002). Inter-coder reliability is an important factor to be considered in content analysis, where it is used as a standard measure of the quality of the research (Lavrakas, 2008). Therefore, two coders independently analyzed the responses that were obtained in the current study to the same set of questions. The agreement of coding the interviews responses of the questions varies from 68% to 86% with an overall agreement

percentage of 80%. When disagreement of the coding occurs, the two coders modified the codes until an agreement is reached. This process helped clarify the coding between the two researchers, where agreements and disagreements helped to attain a common understanding of the respondents' perspectives. Moreover, it also helped to categorize the similar patterns of codes into an integrated category with agreement between the two researchers. Then, we moved to the next part of the analysis: data presentation and interpretation.

3.5.1.2 Data Presentation and Interpretation

The first step of data presentation and interpretation was to provide a table that shows the classification of the categories and the codes for each open-ended question. The table provided an overview of the respondents' perceptions, where the coded perceptions of the two groups of participants (research users and researchers) were presented in different columns. This overview of the data analysis assisted the interpretation of the respondents' perceptions.

The next step of the data presentation and interpretation was within-group analysis. Within-group analysis allows the researcher to explore a phenomena in its bounded context in a single case, whether the case is an individual or a small group. This method provides initial results of what is happening in the case (Miles & Huberman, 1994). In this study, the perceptions of two different groups participants were considered: research users and researchers. The end of each question analysis summarizes the finding. The interpretation of the two groups was vital to attain the aim of the study, which leads to the next step: integrating the finding to draw implications.

3.5.1.3 Drawing Implications

The last step consists of drawing implications by comparing the perceptions of research users and researchers. This employs a comparison of the two units of analysis (researchers and research users). The comparison allows the researcher to distinguish similarities and differences between the two groups, which gives deeper understanding and allows exploration of the analysis groups before conclusions are then drawn (Miles & Huberman, 1994). This step also involved the comparison of the participants' responses regarding the open-ended question and the structured questions. This process permits the researcher to come up with conclusion that attains the aim of the study.

3.5.2 Secondary Method

This method of analysis employed simple statistical analysis using Microsoft Excel to obtain percentages of some answers and provided a graph of the rated perceptions. This method was employed on two questions to obtain rates of the two groups' perceptions regarding the uses of research results and the access to channels of research results. We used simple statistical analysis because the main aim of the study is exploratory in nature, and there was no need to employ any quantitative research methods. The aim of this method was only to check how researchers and research users rate pre-determined uses of research results and how they rate the channels of accessing research results.

Chapter 4: Results

The finding of the study is divided into two chapters. Chapter 4 will present the finding of the uses and access mechanisms of research results. Chapter 5 will present the analysis of the usefulness of research results.

How are research results used and accessed?

This chapter presents some of the findings in two parts. The first part is designed to explore the uses of research results as anticipated by researchers and research users. The second part is designed to explore the access mechanisms for research results from the perspectives of those two groups. The following subsection will provide an overview of the findings of the two parts, which will be followed by summary of the findings.

4.1 The uses of research results

This section describes the findings from exploring the uses of research results from the perspectives of research users and research producers. From the research users' point of view, it explores the uses of research results to identify the main uses. From the point of view of researchers, the objective is to find out how they conceptualize the uses of research results that they produce that are beneficial to users and whether they keep in mind the needs of the research users. As described in the subsections that follow, the interpretation of the findings is constructed on two types of questions: open-ended and structured Likert-scale questions.

4.1.1 Open-Ended Question

Different open-ended questions were asked depending on the participant's category. Research users were asked, "How do you typically use research results?" and research

producers were asked to describe "What use (and by whom) do you anticipate when you produce research results?" By analyzing the answers, several categories were found to identify the uses of research results based on the perceptions of research producers and research users. These categories include research focus, decision support, public outcome, partnering, development and commercialization, and financial assessment, as shown in Table 7.

Table 6 Results Coding: Uses of Research

Category	Code	Frequency of code	
		Research Producers	Research Users
Research Focus	Future research	2	1
	Publication	1	0
	Validation of internal research	1	0
Decision Support	Feasibility assessment	2	1
	Feedstock planting decisions	1	0
	Project assessment	1	0
	Risk assessment	1	0
Public Outcome	Consumer protection	0	2
	Public education	1	0
	Policy development	2	1
Partnering	Collaboration	2	1
Development and Commercialization	Testing for Commercialization	1	0
	Development of new/improved feedstock	4	0
	Development of improved processing methods	3	0
	Technology development	1	1
	Meet demand-side biofuels' specification	0	2
	Commercialize new/improved product	2	3
Financial Assessment	Cost reduction	0	1

The research producers anticipated that research users would have different needs for research results. Their perception was based on the importance of using research results to determine future research, which is assumed to enable them to enhance the level of

improvements of their work. They also expected that research users use research results to confirm or validate their work or research. Also, research producers pointed out the importance of publication in using research results. Research producers also stated the importance of research results to aid research users in decision-making, which provides research users with effective and efficient results that will enhance the decision-making process. For instance, they anticipate that biofuel research users would use research results for feasibility assessments. Furthermore, research producers expect research users, such as policy makers or industry users, to use research results to enhance the utilization of biomass as feedstock to accomplish their own objectives. They stated that research results assist in feedstock planting decisions. Moreover, research producers predict that research results would be used for risk reduction and project assessment, which will aid in avoiding any unexpected issues.

Research producers also anticipated that research users would use research results to educate the public with respect to aspects related to biofuel industry such as biomass. They also indicated that research results would be used by research users to support them develop policies related to biofuels as well as develop a great understanding of the economic. One research producer stated, *"Research users use my research results to understand the economic and to educate the public about biomass" RP#6.* This statement indicates the importance of using research results for public education about the biofuel industry production. The perceptions of research producers revealed that the collaboration between research users and research producers is an important aspect of using research results that can enhance the value of research results. Research producers showed great understanding of

the importance of users using research results to help in joining other collaborations or connect with partners.

Research producers gave considerable attention to the importance of using research results in different stages of production development and commercialization. For instance, they anticipated that research users would use research results to enhance the development of feedstock productivity. They also expect that research results will provide research users with different source materials. Research results were expected to assist research users to alternate the use of low-value waste products in the production process. Research producers anticipated that their research results would be used to help in sponsoring companies interested in developing more technologies. They also expect that the research results would be used to enhance the production process of bioethanol and alcohol, and to improve seed-treatment production. Research producers cited the importance of using research results to assess research users in testing research results to help organizations improve their commercialization processes.

Research users revealed several uses of research results that are assumed to reflect on their needs for research results. Their perceptions relied on the importance of using research results to assist them in deciding on their needs for further research. Research users revealed the importance of using research results for feasibility assessments to support decision-making. They also revealed the importance of using research results to protect their customers. For instance, research users considered the use of research results as a tool for consumer protection, which helps to prevent several contamination issues. They expect that research results would provide them with solutions to any contamination issues related to the

production of biofuels. Moreover, research users revealed the importance of using research results to develop policies related to biofuels.

Another important use of research results that was given considerable concentration is collaboration. Research users anticipated that the use of research results would increase the degree of collaboration between industry and researchers through partnerships. Research users also indicated that the use of research results is important for the development and commercialization of their production processes. For instance, research users indicated that the use of research results helps improve current products as well as the production processes of new products. They also considered the importance of using research results to meet the demand side of production with biofuel specification. Research users also revealed that research results could be used for financial assessments to identify possible cost reductions. They stated, *"We look for efficient cost improvement" RU#2*. They anticipated that the use of research results would increase their profit and reduce their cost of production.

4.1.2 Structured Questions

This type of question employed a Likert-scale design, which identifies six pre-determined uses of research results (Bishop, D'Este, & Neely, 2011) that received attention in the academic literature to check the importance of these uses to research users. The question asked "When you use research results or when your users access your research results, how likely is it that they will use the research results for the following purposes?" These uses of research results include: to improve fundamental understanding of phenomena; to assist in problem solving; as a source of information for suggesting new projects, policy decisions, and cost reductions in product or process development; and to reduce the time

required for completion of a company's R&D projects. The analysis of this question employed a simple quantitative analysis description, as will be shown next.

The analysis indicates that research producers rated the uses of research results as a source of information for suggesting new projects, to reduce cots of products or process development and to assist in problem solving similarly, in the range of 5.42 to 5.67. Research producers gave lower rating, from 4.33 to 4.67, for the use of research results for policy decisions and to reduce the required time for the compilation of company R&D projects. They give the highest rating of 6 to the use of research results to improve fundamental understanding of phenomena.

In contrast, research users give similar ratings – within the range of 5.20 to 5.60 – to improving fundamental understanding of phenomena, assisting in problem solving, and as source of information for suggesting new projects. Research users gave the lowest rating to the use of research results for policy decisions and reducing the time required for compilation of company R&D projects. The highest rating for using research results was given to the use of research results for cost reduction of products or process development.

Analyzing this question revealed that there are some similarities and differences in the participants' perceptions. Research users and research producers gave similar ratings for the use of research results in problem solving and as source of information for suggesting new projects. These two uses of research results were given the same level of importance, however, policy decisions and reducing the time required for R&D completion were given lower ratings. Although the overall responses have similar ratings, some differences can be distinguished between research users and research producers. Research users ranked cost

reduction as an important use of research results more often than research producers. Research producers rated the use of research results to improve fundamental understanding higher than research users. Figure 1 presents the rate of using research results for different purposes from the perspectives of research users and research producers.

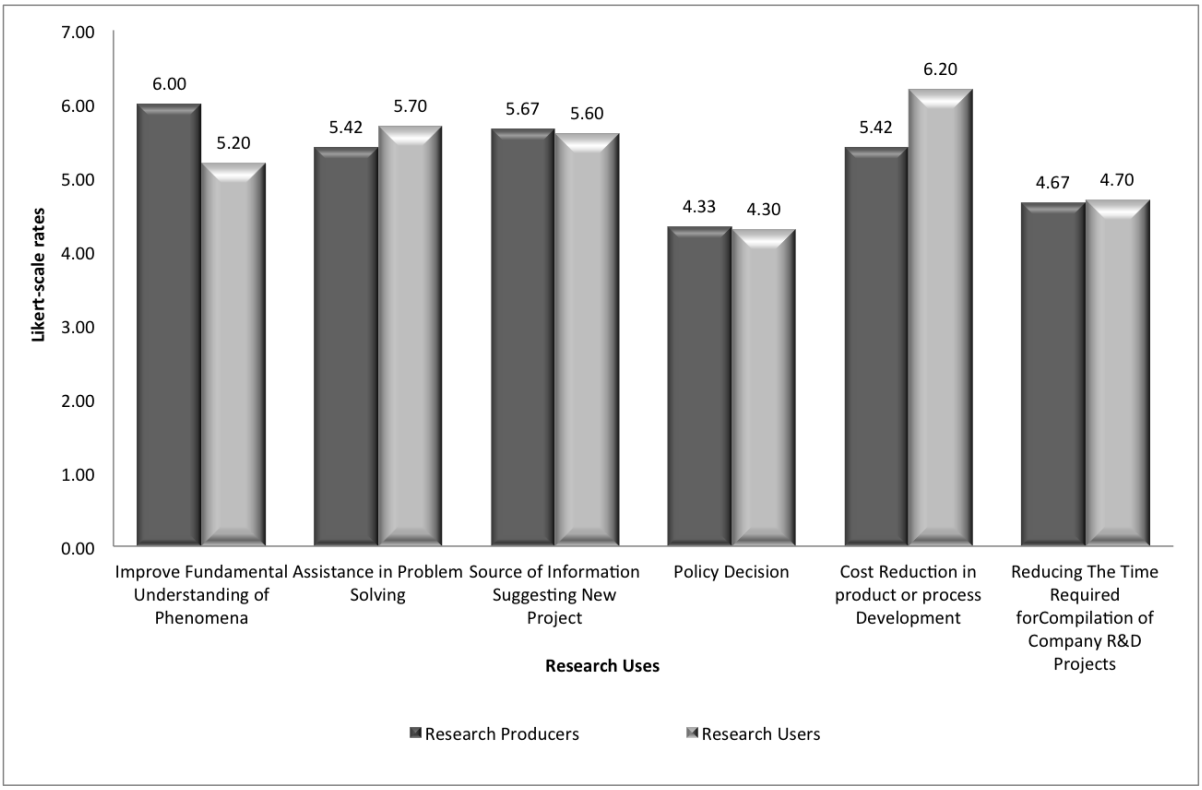

Figure 2 Uses of Research Results

4.1.3 Summary

Based on the analysis of the open-ended question, some similarities and differences arose in the participants' perceptions. Considering the similarities between the two groups of participants' perspectives, the analyses indicate that the uses of research results could be classified as follows: suggesting future researches, feasibility assessment, commercializing and improving products, and policy development.

Although participants revealed similar perceptions, some differences can be distinguished in their responses. For instance, research users anticipated the use of research results for cost reduction, because one of their concerns about using research results is cost improvements. Research users exposed another different aspect relative to research producers, which is related to consumer protection from contamination issues. One of the issues that this industry aims to reach through research is a means of reducing products' contamination issues, which increase product quality (Coradi, de Lacerda Filho, Chaves, & dos Santos, 2014). Research users distinguished another aspect related to the use of research results to meet the demand side of biofuel users' specification. The perspective of research users was mostly focused on aspect related to technical development, production improvement and commercialization use of research results. This finding can give insights into their aims for production improvements to enhance commercialization.

However, research producers anticipated some different uses of research results that were not mentioned by research users. These uses included the use of research results for validating the entire work of research users. Research producers also emphasized the use of research results to improve processing methods and tests for commercialization.

4.2 The Mechanisms for Accessing Research Results

The question related to the mechanisms for assessing research results was asked slightly different version for each category. Research users were asked to indicate how they assess the mechanisms for accessing research results. Research producers were asked to make best-possible guesses as to how their intended users might consider these mechanisms. The questions aim is to determine the mechanisms that research users use to access research

results from the perspectives of research users and research producers' perspective. Four main access mechanisms for research results were considered in this section: academic conferences, academic journals, academic books and direct communication with researchers. The study assessed these mechanisms of accessing each source regarding its ease of access, relevance, credibility and frequency of access for research users. The analysis of this question employed a simple quantitative analysis description, as will be shown next.

From the perspectives of research producers, the four access mechanisms depend on their relevance, ease of use, credibility and frequency of access. Regarding the mechanisms of accessing research results in term of their ease of use as shown in Figure 3, research producers rated academic journal articles and direct communication with researchers as the two highest-rated ease-of-use mechanisms. They gave less importance to academic conferences as an access mechanism, whereas the lowest ratings were given to academic book. Considering the credibility of accessing mechanisms of research results as shown in Figure 2, research producers give the highest rating of 6 to academic journal articles and direct communication with researchers. They gave lower priority to accessing research results through academic books and academic conferences. In terms of the relevance of access mechanisms of research results as shown in Figure 5, research producers gave the highest ratings to academic journal articles, with a slightly lower priority given to direct communication with researchers. Academic conferences obtained a rating of 4.77 which was less than 5.08 of direct communication with researchers. Research producers give the lowest rating of 3.69 to academic books. Regarding the frequency of access mechanisms of research results, research producers gave the highest rating to direct communication with researchers followed by academic journal articles. They give less importance to the frequency of

accessing research results through academic conferences. Academic books gained the lowest ratings for frequency of access to research results.

From the perspective of research users, they elaborated the four access mechanisms that depend on: relevance, ease of use, credibility and frequency. Regarding the mechanisms of accessing research results in terms of their ease of use as shown in Figure 3, research users gave the highest importance to accessing research results through academic journal articles. They gave similar ratings for ease of use to academic books and direct communication with researchers to access research results. They gave less importance to accessing research results through academic conferences in term of ease of use. Considering the credibility of accessing mechanisms of research results as shown in Figure 2, research users gave all the four access mechanisms similar ratings for their credibility, whereas a slightly higher rating was given to academic journal articles and direct communication with researchers. In term of the relevance of access mechanisms of research results as shown in Figure 5, research users gave academic journals, academic conferences and direct communication with researchers very similar ratings in terms of their relevance. They rated academic books as the least relevant access mechanism for research results. Regarding the frequency of access as shown in Figure 4, research users rated the frequency of accessing research results through direct communication with researchers as the most frequent channel. They rated academic journal articles as the second highest mechanism for accessing research results. They revealed that academic conferences and academic books are the least used access channel for research results.

Next, another question was asked of the participants: “Does the above reasonably reflect your pattern of access to research results?” The analysis of the participants’ responses

revealed that 80% of research users agreed that the access mechanisms of research outputs reflect their patterns of accessing research outputs. The perceptions of research producers revealed that 55% anticipated that the mechanisms of accessing research results would reflect patterns to access research outputs.

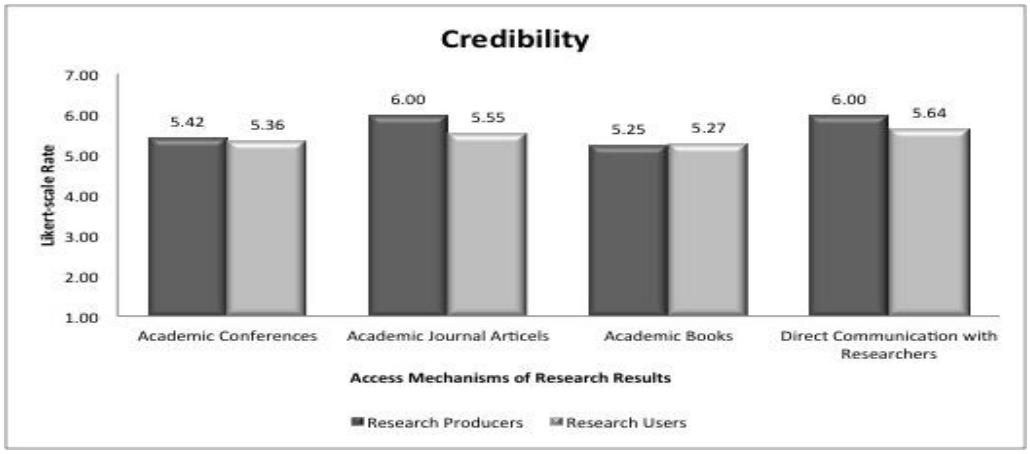

Figure 3 Mechanisms of Accessing Research Results: Credibility

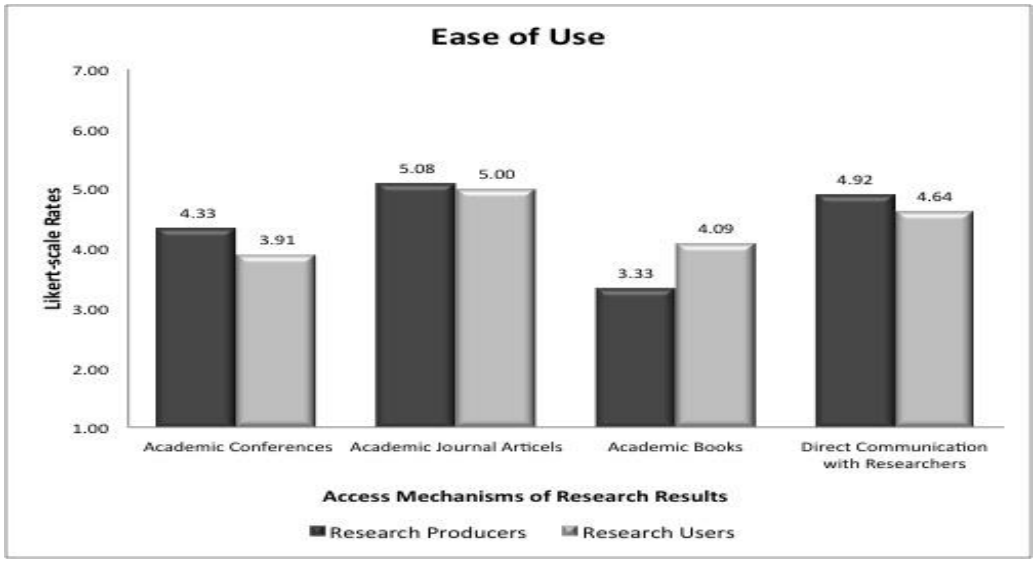

Figure 4 Mechanisms of Accessing Research Results: Ease of Use

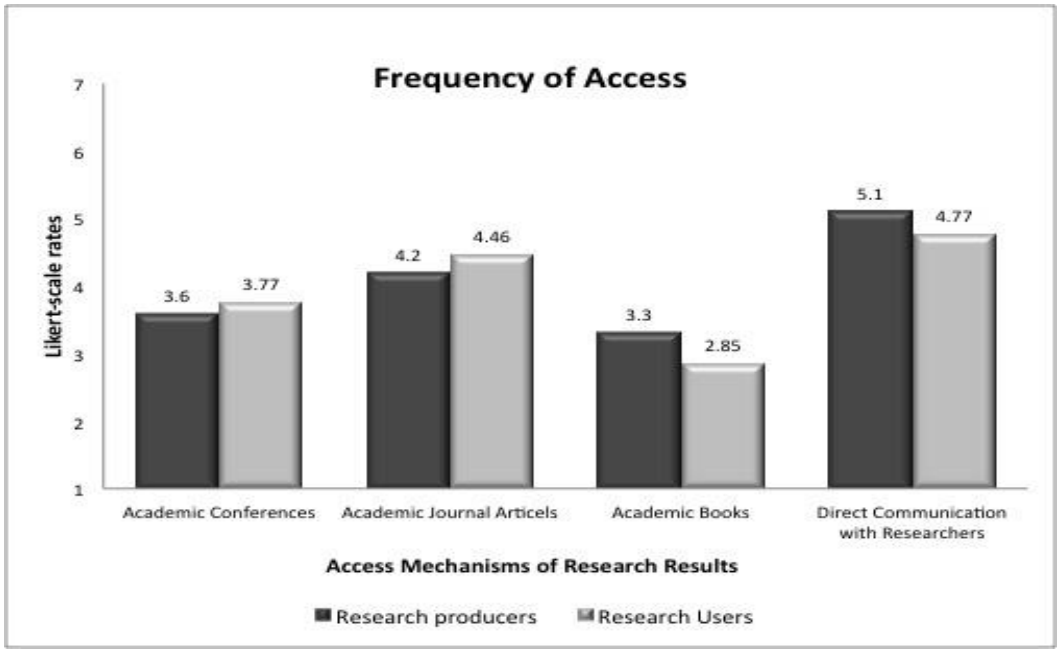

Figure 5 Mechanisms of Accessing Research Results: Frequency of Access

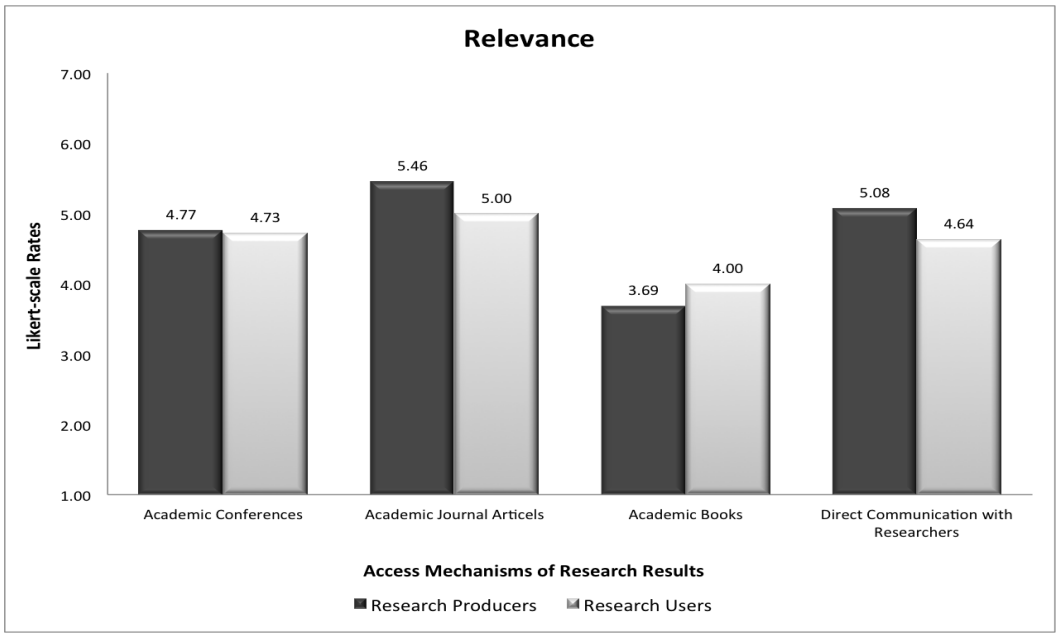

Figure 6 Mechanisms of Accessing Research Results: Relevance

Summary

Overall, the analysis of the access mechanisms of research results indicated that research producers and research users rated the channels similarly. They revealed that the most important channels for accessing research results are academic journal articles and direct communication of researchers in term of their credibility, ease of use, relevance and frequency of access. Research users and research producers rated academic conferences as a channel for accessing research results similarly where they give a high rating for its credibility. However, they give lower ratings to the ease of use, relevance and frequency of accessing research results through academic conferences. In terms of credibility, academic books were given a similar rating as the other channels for accessing research results; however, they obtained the lowest ratings for their ease of use, relevance and frequency of access from the perspectives of research producers and research users. Even though accessing research results through academic books was given the lowest rating amongst the other channels in all the categories, research users rated this channel higher that research producers. Direct communication with researchers obtained a slight higher rate from the perspective of research producers than research users in term of their credibility, ease of access and relevance. However, research users rated direct communication with researchers in term of their frequency of access higher than research producers. Research users give higher ratings to the frequency of accessing research results through direct communication with researchers than to academic journal articles.

Chapter 5: Results

The Usefulness of Research Results

This chapter presents the findings of the usefulness of research results anticipated by research users and researchers. From the perspective of research users, it explores how they conceptualize the usefulness of research results. From the perspective of researchers, it explores how researchers conceptualize the usefulness of their research results to research users. The interpretation of the findings is constructed on two types of questions: open-ended and structured. The interpretation of the findings in this chapter is divided into two subsections. Each subsection will involve an explanation of one type of question and involve subsections of interpretation of the findings.

5.1 Open-Ended Question

This type of question asked participants of the two groups "What makes research results useful?" in order to obtain a general conceptualization of the usefulness of research results. By analyzing this question, several important aspects regarding the usefulness of research results were identified. These aspects were coded and grouped into four main categories: financial assessment, technical issues, societal issues and transfer processes as shown in Table 8. The following subsections will provide an explanation of each category followed by interpretations of the within-case analysis of each group of participants (research users and research producers).

Table 7 Usefulness of Research Results Coding

Category	Code	Frequency of code	
		Research producers	Research Users
Financial Assessment	Cost reduction	3	5
	Risk reduction	1	2
	Economic feasibility	3	1
Technical Issues	Technical needs	3	3
	Compatibility	3	2
	Scalability	1	1
	Improvements	2	0
Societal Issues	Sustainability	1	1
	Impact assessment	2	1
	Social issues	2	0
Transfer Processes	Communication	1	1

Research producers anticipated that research results would be useful for research users by addressing aspects related to four main issues: financial assessment, technical issues, societal issues and transfer processes. In terms of financial assessment, research producers indicated the importance of research results in providing research users with financial assessment. For instance, it is expected that research users would take into consideration the financial implication of the research results in term of financial issues resulted of implementation such as cost reduction implied by the research. Another aspect that research producers consider as an important issue is risk reduction. One stated, *"What is the risk of*

new technologies taking away my market?" RP#12. Research producers expect the research results to provide a demonstration of commercialization viability and economic value.

Research producers also related the usefulness of research results to their ability to address technical issues. They expect research results to provide demonstrations of technical feasibility. In particular, they considered the importance of improving crops and reducing the materials used for the production. Research producers expect research results to overcome technical barriers, enhance knowledge and develop new innovations. They stated that a useful research result would provide with the potential and limits of their productions or implementation of new technologies. Research producers also exposed the importance of research results to provide scale demonstrations to industry.

Another issue that research producers assumed to influence the usefulness of research results is the ability of research results to assist social issues related to biofuels sector. For instance, research producers revealed the importance of research results to enhance sustainability**.** They also expect research results to provide suggestions for improvements to the current biofuels and overcome shortfalls in their current systems. Research producers also considered the resulting impacts of the research results on the economy. A research producer exposed the impact of research results on the public and private sectors, and on farming in particular:

> *"Public sector: estimated impact on GDP and employment. See how policies affect macro indicators. Private sector: indicators, prices, competitiveness of industry relative to international competition, own feasibility, and business strategy. Farms: impact of second-*

generation of biofuels and impact agricultural (ag) business." RP#12

Research producers also assume that the processes in which research results are transferred influence the usefulness of research results. For instance, the clarification of research results is a prominent aspect that enhances the usefulness of research results. Research producers argue that the clarity of communication between research users and research producers in the form of clear articulation of the impact of using research results has a major influence on the usefulness of research results. A research producer stated:

"I cannot expect the end-user just to pick up our information and know what it means. We have to be clear about what we found and what it means." RP#6

They also identified the importance of clear presentation of the results, the availability of technology transfer documents and the provision of interactive web tools to access the results. As well, the research results should be transformed into a form of interpreted science to make it accessible. For instance, research results should be transformed into a language that can be simply understood by research users.

Research users expected research results to meet their specification at an acceptable cost. Also, they considered it vital that research results should provide them with adequate financial return by reducing the costs of the production process. Research users stated that the significance of research results is to minimize the risk of contamination issues and not cause harm. Research users also considered several technological specifications that would make research results useful, including the ability of research results to provide a consistent process, higher ethanol concentration, and faster conversion.

Research users also considered the practical importance of research results. Research users revealed that these results have great impact on their work where they can help scale up processes, reduce down time, improve actual work processes, and be applied. They expect research results to suggest hybrid technologies to improve current production processes. Research users indicated that research results could enhance environmental sustainability. They expect that research result to be beneficial and provide viable policies. Research users revealed that research results are useful when they are presented in an understandable form. One research user stated:

> *"Research results are most useful when presented so we can understand all the consequences: intended and unintended, so the policy is viable." RU#7*

Summary

Based on analyses of the aspects that make research results useful, some similarities and differences arise from the participants' responses. Considering the similarities between the perspectives of the two groups of participants, the analyses indicated that research users and research producers identified similar aspects related to useful research results. These similarities consist of the importance of research results to provide research users with four main aspects related to financial assessments, technical issues, societal issues and transfer processes. In terms of financial assessment, research users and research producers agreed on the importance of research results to reduce costs associated with their production processes and the returns on their investments. Regarding technical issues, the two groups had similar perceptions that research results are needed in order to improve technical issues that result in process improvements. Considering their perceptions on the societal issues, they hold

similar perspectives that research results would be useful when they enhance sustainability. Transfer processes are another aspect that both groups of participants stated similarly. They illustrated the prominent need for clear understanding of research results by providing a clear explanation of the consequences of using research results and providing the result in an understandable form of knowledge.

Although participants revealed similar perceptions, some differences can be distinguished in their responses. For instance, research users and research producers exposed the importance of risk reduction as a determinant of useful research results; however, they identified different points of view of risk reduction. Research users disclosed the importance of risk reduction in order to prevent their customer from encountering contamination issues associated with their products. On the other hand, research producers shown the importance of the technological risks associated with implementing research results which might results in taken away some aspects from the research users' market. Societal issues were another aspect that was considered differently between the two groups. Both groups of participants identified the importance of this aspect, however, research producers mentioned the importance of research results having an impact on the economy, and on the public and private sectors, and on farming in particular.

5.2 Structured Questions

A set of six structured questions was derived from the literature of DoI, TAM and PCI to explore the assessment criteria used by research users and research producers to assess early-stage research results. As mentioned above, we used usefulness, ease of use, compatibility, relative advantage, status and quality dimensions to ask participants their

perceptions of assessing early-stage research results. Each dimension included several categories. The analysis on the obtained responses regarding to these dimensions were coded and categorized into several categories as shown in Table 9. The following subsections will elaborate on each of these dimensions' categories.

Table 8 TAM and PCI Dimensions Categories

TAM/PCI	Category
Usefulness	Technology development
	Financial performance
	Collaboration process
	Quality
	Originality
	Relevance
Ease of Use	Financial performance
	Transformation process
	Implementation
Relative Advantage	Financial performance
	Technical improvement
	Closeness to industry
	Policy contribution
	Reputation of the researchers
Compatibility	Financial performance
	Technical development
	Project analysis framework
	Demand framework
Status	Financial performance
	Closeness to industry
	Quality
	Commercialization development
	Recognition
Quality	Scientific Method
	Applied nature of research
	Reputation
	Closeness to industry
	Financial performance
	Academic standards

5.2.1 Usefulness

This dimension asked participants "How do you assess **how useful** certain biofuel research results are going to be? What characteristics make research outputs useful to you / the intended users?" Its aim is to explore (or investigate) the assessment criteria that participants use to assess the usefulness of certain biofuel research results. As shown in Table 10, by analyzing this question, several categories were identified: technology development, financial performance, collaboration process, quality, originality and relevance.

Table 9 Usefulness Dimension Coding

Category	Code	Frequency of code	
		Research producer	Research Users
Financial Performance	Cost reduction	4	1
Technical Development	Compatibility	1	0
	Scalability	1	1
	Time to market	0	1
	Ease of implementation	2	0
Quality	Accuracy	3	2
	Replicability	0	1
Collaboration Process	Communication	2	1
	Project management	0	1
Originality	Patentable	1	0
	Innovativeness	3	0
Relevance	Relevance	5	1

Research producers exposed that research results would be useful when they provide certain aspects related to technology development, financial performance, quality of the results, collaboration, originality and relevance. In term of technology development, they expects that research users would assess the usefulness of research results based on their ability to provide easily implemented solutions. The ease of implementation could lead to the identification of new policy opportunities. Research producers also identified the importance of research results in enhancing the potential economic growth of the biofuel industry by implementing solution that are scalable.

Considering the financial performance of research results, research producers revealed the importance of cost reduction. For instance, they emphasized the importance of research results in reducing feedstock costs for biofuel production as a means of assessing the usefulness of research results. Research producers related another aspect to assess the usefulness of research results, which is the collaboration between research producers and research users. They considered clear communication between themselves and research users as a significant aspect. They expect that, if research results have an impact on users, it will mean that these results provided useful information for research users. Therefore, they consider clear communication as an important factor to assess the usefulness of research results. Communication in this aspect means clear understanding of research producers' messages through their research results or research.

The quality of the research results is another aspect that research producers related to the assessment of usefulness. They indicated that the quality of the journal that the research results are published in could have an influence on the usefulness of research results. They considered that not only the quality of the results would enhance the usefulness of research

results but also the quality of the journal as well. Besides the above-mentioned issues to assess the usefulness of research results, research producers considered the originality of research results. They revealed that the novelty of research results could enhance biofuel production. Moreover, research producers indicated that research results would be useful when they are different than other studies. In addition, patenting of the research results also is an important criterion to assess the usefulness of research results. The last aspect that was mentioned by research producers to assess the usefulness of research results is relevance. They exposed that the relevance of research results to research users would be used as an assessment for its usefulness. For instance, the ability of research results to address research users' needs would be an important assessment for its usefulness.

Research users assess the usefulness of research results based on financial assessment, technology development, quality, collaboration and relevance. In term of financial assessment, they indicated that the usefulness of research results depends on its return on investment. Moreover, they expect that research results would be able to provide cost improvement, which indicates the importance of cost reduction as an assessment criterion of usefulness. Research users also considered the importance of technology development as an assessment of usefulness. Furthermore, they indicated that the scalability of research results is an important aspect in assessing the usefulness of research results, along with the time spent applying the research results. Another main aspect to determine the usefulness of research results is the collaboration between research producers and research users. They expect that the collaboration underline aspects related to ease of understanding the published results. Also, the identification of a clear project plan at the beginning of the project is considered a tool to assess the usefulness of research results. Research users considered the

significance of the accuracy and consistency of research results which reflects on its quality as a criterion to assess the usefulness of research results. In addition, they considered the replicable research results to be useful.

Summary

The analysis of this dimension indicated that research users and research producers identified similar aspects related to the usefulness of research results. These similarities consist of the importance of assessing the usefulness of research results depending on several aspects related to financial assessments, technological development, collaboration process, quality and relevance. In terms of financial assessments, research users and research producers stated the importance of cost reduction to enhance the usefulness of research results. Considering the technological development aspect, both groups of participants indicated the importance of scalability. The collaboration process is another aspect that was given considerable attention from the participants. They emphasized the importance of clear communication for understanding or transferring the results. Both groups hold similar perceptions regarding the quality of research results where they implied the significance of research result accuracy as well as its ability to address research users' needs.

Although participants revealed similar perceptions, some differences can be distinguished in their responses. For instance, research users considered that the time required to implementing research results would have an effect on its usefulness in terms of technological development. They also indicated the identification of a clear project plan at the beginning of a project. On the other hand, research producers expect that ease of implementation and compatibility of research results are aspects that can be considered in

terms of technological development and usefulness. Another aspect that was given attention by this group that was not considered by research users is the originality of research results. They indicated that this aspect is an important determinant of usefulness.

5.2.2 Ease of Use

This dimension asked participants "What criteria do you use to assess how **easy to use** new biofuels research results are going to be?" Its aim is to investigate the assessment criteria used by research users to assess the ease of use of research results and how research producers anticipate research user's criteria for assessing the ease of use of research results. By analyzing this question, several categories were identified: financial performance, transformation processes and implementation as shown in Table 11.

Table 10 Ease of Use Dimension Coding

Category	Code	Frequency of code	
		Research Producers	Research Users
Financial Performance	Cost reduction	2	0
Transformation Process	General reporting	0	3
	Documentation form	2	2
	Project management	1	0
Implementation	Relevance	1	1
	Fit with capacity	3	1
	Scalability	1	1

Research producers anticipated that research results would be easy to use when they provide advantages related to financial performance, ease of transferring research results and ease of implementing the results. In terms of financial performance, research producers highlighted the importance of cost on the ease of use of research results. For instance, they

expect that cost reductions in production would improve the ease of use of research results, which indicates that cost-effective solutions would facilitate the use of research results. Regarding the ease of transferring research results, research producers indicated the importance of the form in which the research results would be presented to research users. They expect that research users assess the ease of using research results depending on different criteria. These include a simple form and language for presenting the results. They also take into consideration the different forms of documenting the results such as policy-relevant terms. Furthermore, they expect that clear identification of the project objective and meeting the objective of the study is an important factor to consider when assessing the ease of using research results. Research producers considered the ease of implementing research results would be used to assess the ease of use. They consider that the implementation of research results depends on several aspects, which include relevance and scalability. Research producers anticipate that research users consider the importance of quality in assessing the ease using of research results. They measure the quality of the results depending on their applicability to an industry scale and the use of technologies that simplify the use of research results by industry. The relevance of these results to the needs of industry users and to the issues related to the needs of biofuel research users would ease the use of research results. Research producers also expect that the quality of journal that a research result is published in is an important aspect to assess the ease of using research results.

Research users indicated the assessment of research results ease of use through two aspects: the ease of transferring research results and the ease of implementing the results. In term of ease of implementing research results, they revealed the importance of documenting research results in different forms that have understandable terms for policy and industry

users. They also take into account the use of graphs and charts to simplify the presentation of the results. In addition, they considered the provision of complete information about the results in a well-written report an important aspect. Considering the implementation of research results, they emphasized the importance of research results to enhance knowledge of user needs. In addition, the significance of the reliability and consistency of research results and their ability to match the existing capabilities of research users was considered an important aspect. Research users take these aspects into consideration when assessing the ease of using research results.

Summary

The analysis of this dimension indicated that research users and research producers identified similar aspects related to the ease of using research results. These similarities consisted of the importance of assessing the ease of using research results depending on several aspects related to the transformation process and implementation. In term of the transformation process, research users and research producers hold similar perceptions regarding the importance of the different forms by which the data can be presented and the value of documenting results. Implementation of research results is another aspect that was considered important in order to assess the ease of use criteria.

Although the participants revealed similar perceptions, some differences can be distinguished in their responses. For instance, for Rogers (2003), complexity is a critical dimension that is negatively related to the adoption process. However, in this study, a research user indicated that “difficult to use is good, keeps competition out.” This response implies that ease of use is not necessarily an important factor. The rationale is that each firm

in the biofuel industry is competing to maximize its profit. Therefore, if the research result is difficult to use but is understandable by few firms, it will restrict the market share to those who understand it, thereby enhancing their profit. This participant works as an intermediary actor: a knowledge broker whose function is to bridge the transfer of knowledge from researchers to users. Knowledge brokers assist the process of knowledge exchange to be beneficial to knowledge users by identifying needs, sharing ideas and forming strong links between science producers and users. These factors are in addition to simplifying the use of research results by presenting them in understandable language to the user (Bielak, Campbell, Pope, Schaefer, & Shaxson, 2008).

On the other hand, research producers considered financial performance as an aspect to assess the ease of using research results where they anticipated that research users would assess ease of use through cost reduction. Another aspect that was considered by this group was project management. And, another difference occurred in a research producer response that assessing the ease of use is not the researcher's criteria to determine, it depends on the research users. This respondent stated that:

> *"As a person providing the result, I will be having to count on the industrial partner to assist and determine this criterion. It is not the producers only to decide about this criterion on the need of end user. It has to be driven by the end user." RP#5*

However another research producer indicated the importance of communicating with research users in order to ease the use of research results. This respondent stated:

> *"How many times do they have to call; we ask how they use info - what they need; we provide it in a language they can understand." RP#10*

This response shows that research producers are concerned about producing research results and they confirm the ease of use by communicating with research users. Thus, having an industry partner will ease the use of research results.

5.2.3 *Compatibility*

This dimension asked participants "What criteria do you use to assess whether biofuels research results are **compatible** with your/your intended users' existing technologies or frameworks?" Its aim is to investigate the assessment criteria of using research results to enhance compatibility of research results to research users. As shown in Table 12, several categories were identified: project analysis framework, technical development, financial performance and demand frameworks.

Table 11 Compatibility Dimension Coding

Category	Code	Frequency of code	
		Research Producers	Research Users
Project Analysis Framework	Analytical models	2	0
	Canadian policy needs	1	0
	Project management	1	0
Technical Development	Sustainable	0	1
	Scalable	0	1
	Technology infrastructure	3	3
Financial Performance	Cost expectation	1	1
Demand Framework	Costumer request	2	2
	User-specific	1	0
	Available feedstock	0	1

Research users indicated that the compatibility of research results would be assessed through the project analysis framework, technical development, financial performance and demand framework. In term of the project analysis framework, research producers indicated that the compatibility of research results depends on several aspects related to the employed framework. For instance, they considered the capability of research results to have a specified objective and a clear project plan as compatible research results. They also mentioned the importance of analysis norms to match Canadian industry norms. Also, they believe that the analysis of research results needs to match the industry analysis models.

Considering technical development to assess the compatibility of research results, research producers anticipated the importance of research results to match the existing technology with some improvement. For instance, they cited that research results would be compatible when they align with current industry technologies or provide newly developed technologies. On the other hand, some of the research producers mentioned that there are no specific criteria to assess the compatibility of research results. This is due to the various needs of research users for research results. Research producers stated that compatibility is a moving target that involves a multidisciplinary dialogue. In addition, research producers think that research users have a specific matrix to assess compatibility, where they compare the research results with their matrix.

Regarding the assessment of the compatibility of research results through financial performance, research producers indicated the importance of cost expectation. For instance, they revealed that research results would be compatible when they result in reduces costs (e.g., drop-in fuels that are interchangeable with gasoline). Therefore, they expect that research results that reduce the cost of production would be compatible to research users.

Another aspect that is considered when assessing the compatibility of research results is the demand framework. Research producers anticipated the importance of research results in meeting research user' needs as a measure of compatibility. Consequently, they check research users' requirements of using research results and produce their research accordingly. This would make research results compatible with research users.

Research users anticipated assessing the compatibility of research results through technical development, financial performance and a demand framework. In terms of assessing the compatibility of research results through technical development, research users anticipated the importance of research results in matching the existing technology with some improvement. For instance, they highlighted the prominent role of research results in providing sustainable input. Research users also would require the research results to provide descriptions of bio-production knowledge such as descriptions of the chemistry involved. They expect research results to be applied and compatible with the existing infrastructure. Regarding the use of financial performance to assess the compatibility of research results, research users indicate that implementing research results with no extra cost would be used as an assessment criterion of research results compatibility. Another aspect that research users give attention to is the assessment of the compatibility of research results using a demand framework. For instance, research users expect that research results will be produced in accordance with their needs and will therefore be compatible.

Summary

The analysis of this dimension indicated that research users and research producers identified similar aspects related to the compatibility of research results. These similarities

consist of the importance of assessing the compatibility of research results depending on several aspects related to technical development, financial performance and a demand framework. In terms of technical development, research users and research producers indicated the importance of research results to match the existing technology infrastructure. Financial performance is another aspect that was similarly perceived by both groups of participants when assessing the compatibility of research results. They revealed the importance of cost reduction in the process of implementing research results. Both groups hold similar points of view regarding a demand framework: they give considerable attention to the importance of research results in meeting the demand side of the users' needs.

Although participants revealed similar perceptions, some differences can be distinguished in their responses. For instance, research users indicated the importance of research results to enhance sustainability, which was not considered by research producers. On the other hand, research producers anticipated the significance of the projects' analysis framework as an important measure of the compatibility of research results.

5.2.4 Relative Advantage

This dimension asked participants "What criteria do you use to assess whether they have a **relative advantage** over research results you have previously known about? What does relative advantage mean to you?" Its aim is to investigate the assessment criteria of using research results to enhance research users' relative advantage of research results. Several categories were identified including financial performance, technical improvement, closeness to industry, policy contribution and researcher reputation, as shown in Table 13.

Table 12 Relative Advantage Coding

Category	Code	Frequency of code	
		Research producer	Research users
Financial Performance	Cost reduction	4	2
Technical Improvement	Production improvement	1	0
	Accuracy, improve quality, better results	1	0
	Novelty	1	0
	Facilitate feedstock streams	1	0
Closeness to Industry	Scalability	0	1
	Usefulness	0	1
	Difficult to use	0	1
	Problem solving	1	2
Policy Contribution	Economic impact assessment	2	1
	Macro/policy contribution	1	0
Researcher Reputation	Researcher reputation	1	0
	Level of funding	1	0

Research producers anticipated assessing the relative advantage of research results through financial performance, technical improvements, closeness to industry, policy contribution, and researcher reputation. In terms of using financial performance to assess the relative advantage of research results, research producers anticipate the importance of cost. For instance, they expect that reducing the costs of producing and commercializing biofuels is an important assessment criterion for relative advantage.

Considering the technical improvement of research results as an assessment of relative advantage of research results, research producers anticipate that there are several important

technological improvements, including production improvement, quality of results, novelty and facilitated feedstock streams. Closeness to industry is another aspect that research producers related to the assessment of the relative advantage of research results. Research producers expect that research users will assess the relative advantage of research results depending on how well the research results meet industry needs. Moreover, they also consider the ability of research results to address issues related to the industry. Another aspect that research producers implied to assess relative advantage of research is policy contribution. An alternative aspect that is also assumed to assess the relative advantage of research results is the reputation of researchers. Research producers anticipate that the reputation of the researchers and their institutions have an impact on the perceived relative advantage of research results. They also expect that the quality of the journal publishing the results is essential. In addition, the level of funding also used to assess the relative advantage of research results.

Research users indicated that the relative advantage of research results could be assessed through two main aspects: technical improvement and closeness to industry. In terms of assessing relative advantage through technical improvement, research users stated that the relative advantage of research results depends on its ability to enhance biofuel technology to accelerate the fermentation rate. In addition, they identified the ability of research results to increase the yield during biofuel production and assist in decreasing the use of chemicals in the production process. Moreover, research users indicated the significance of comparing the existing production process with the provided research results to observe the obtained benefits. Another aspect that research users related to assess the relative advantage of research results is closeness to industry. Research users revealed the importance of research

results' relative advantage in addressing issues related to their field and providing results that are useful. On the other hand, some research users mentioned that complicated research results might provide them with a relative advantage if using the results provides challenges to the industry.

Summary

The analysis of this dimension indicated that research users and research producers identified similar aspects related to the relative advantage of research results. These similarities consist of the importance of assessing the relative advantage of research results depending on several aspects related to financial performance, technical improvements and closeness to industry. In terms of financial performance, research users and research producers revealed the importance of this aspect in enhancing their relative advantage of research results. They also emphasized the significance of reducing production and commercialization costs. Another aspect that was given a similar level of attention from both groups of participants was technical improvement, where they anticipated the importance of research results in providing several technical aspects such as accelerating the fermentation process and facilitating the use of feedstock streams. Both the groups hold similar perceptions regarding the importance of research results in addressing issues related to the industry in order to enhance relative advantage of research results.

Although participants revealed similar perceptions, some differences can be distinguished in their responses. For instance, a research user indicated that complicated research results would provide a relative advantage as they will provide challenges in the industry to use the

research results. On the other hand, research producers stated different aspects that research users did not consider, such as policy contribution and researcher reputation.

(Rogers, 2003) stated "relative advantage is a ratio of the expected benefits and the costs of adoption of an innovation" (p. 233). Sub-dimensions that are usually identified under relative advantage include time saving, cost reduction, and economic profitability. The findings of this study from the perspective of research users confirm some of these aspects, where research users identified cost reduction and economic assessment as two assessment measures of the relative advantage of research results.

5.2.5 Status

This dimension asked participants "How do you assess whether using specific biofuel research results would enhance your **status or respectability (credibility)**?" Its aim is to investigate the assessment criteria of using research results to enhance the status of research users. Several categories were identified, including financial performance, closeness to industry, quality, commercialization development, research association and recognition, as shown in Table 14.

Table 13 Status Dimension Coding

Category	Code	Frequency of code	
		Research producers	Research users
Financial Assessment	Profit increase	0	1
Closeness to Industry	Relevance	1	0
	Demand for service	1	0
	Value added to partner	1	1
	Address gaps	1	1
Research Association	Increase R&D capacity	1	0
	Association with professor	2	1
Research Value	Quality of data/results	4	2
	Reliability of results	1	5
	Novelty	1	0
Commercialization Development	Quality of publication	1	0
	Patenting	1	0
	Commercialization track record	1	0
Recognition	Government involvement	1	0
	Industry recognition	2	0
	Neutral party status	1	0

Research producers anticipated assessing the status gained from research results through closeness to industry, research value, commercialization development, recognition and research association. In terms of assessing the enhancement of status from research results, research producers highlighted the significance of meeting the needs of research users. For instance, they anticipate that research results would enhance the status of research users when they increase the demand for the services they provide to their customers. They also expect that research results deliver information need by research users. Research producers

indicate that the ability of research results to be easily applied would enhance the status of research users and research producers. Moreover, they anticipated that the ability of research results to address needs or gaps would enhance the status of research users and research producers.

Regarding assessing the status of research users through research value, research producers indicated the importance of research result quality. For instance, they highlight the importance of publishing research results in high-impact journals, which reflect on the quality of research results. However, some research producers contradicted this view that the publication venue has an impact on the status of research users. Another aspect that is considered when assessing the status of research users is commercialization development. For instance, research producers highlighted the importance of the commercialization process in enhancing the status of research users. They indicated that research results would enhance the status of research users by providing them with the use of patented research results. They also emphasized the importance of commercialization track record.

Research users indicated assessing the status gained from research results through financial performance, closeness to industry and research value. In terms of financial assessment, research users highlighted the importance of financial aspects in enhancing status of research users. For instance, research users implied that research results would enhance their status if research results give them the efficient profit they expected. Another aspect that research users took into consideration when assessing status is closeness to industry. Research users indicated that research results would enhance their status by providing results that improve existing data. They also expect that research results would overtake the shortfalls of their work with enhancement to their business as well as through

the development of new research. Value of research is an alternative aspect that research users assumed to be used to assess the status of using research results. Research users indicated the importance of quality of data would to enhance their status, where they look for solid, replicated and consistent data. They also expect the research results to provide them with reliability of technology and predictability in application.

Summary

The analysis of this dimension indicated that research users and research producers identified similar aspects related to the compatibility of research results. These similarities consist of the importance of assessing the compatibility of research results depending on several aspects related to closeness to industry, research association and research value. In terms of closeness to industry, research users and research producers highlighted the importance of research results to overcome the shortfalls in the existing system in order to enhance their status. Another aspect where the groups hold similar perceptions is research association, where they give attention to the significance of collaboration between researchers and research users.

Although participants revealed similar perceptions, some differences can be distinguished in their responses. For instance, research users highlighted the importance of research value in terms of research results to provide them with solid, replicated and consistent data. They also revealed the importance of research results to increase profit in order to enhance their status. On the other hand, research producers stated the importance of publication in terms of research value in order to enhance the status of research users. Research users also emphasized the importance of commercialization development, which was not considered by

research users. Some research producers indicated that high-impact publications would enhance their status, however, other research producers in the same field stated that publication venue is not an important factor to assess the status. They indicated that there are more important factors to enhance the status of using biofuel research results such as the commercialization track record, increased demand for services and increased R&D capacity. Research producers also anticipate that the involvement of government would enhance the status of their research users because governments see universities as independent sources of information. This implies that research results produced in universities can be seen as reliable sources of information.

5.2.6 Quality

This dimension asked participants "What criteria do you use to assess the **quality** of research results?" Its aim is to investigate the assessment criteria used to assess the quality of research results. Several categories were identified under this dimension, including scientific method, results utilization, reputation, closeness to industry, financial performance and academic standard, as shown in Table 15.

Table 14 Quality Dimension Coding

Quality	Code1	Frequency of Code	
		Research Producer	Research Users
Scientific Method	Scientific rigor	5	3
	Result examination	2	0
Results Utilization	Applied	1	1
	Can be demonstrated	0	2
	Scalability	1	2
Reputation	Industry recognition	1	0
	Reputation	1	0
	Media coverage	1	0
Closeness to Industry	Novelty	2	0
	Effectiveness in addressing problem	2	2
Financial Performance	Value for money	1	1
	Value added to partner	2	0
Academic Standard	Publication quality	6	2
	Success with funding	1	0

Research producers indicated the assessment criteria of research results quality through scientific method, results utilization, reputation, closeness to industry, financial performance and academic standards. In term of the scientific method, research producers highlighted the importance of research results in following scientific procedures in order to enhance the quality of research results.

They also cited the significance of peer review validation as well as the importance of reproducibility. Regarding assessing the quality of research results through results utilization, research producers considered the importance of application and scalability to enhance the usefulness and quality of research results. A research producer stated,

"Research results should be applied because if it is not applied that means it is not useful for public." RU#2

Another aspect that research producers assumes that research users would use to assess the quality of research results is reputation. They revealed the importance of the reputation of research results to assess the quality of research results. Research producers considered three factors when assessing the quality of research results: industry recognition, reputation and media coverage. An alternative aspect to assess the quality of research results is closeness to industry. Research producers highlighted the importance of research results to be close to the needs of research users. For instance, they consider the effectiveness of research results to address problems associated with research users and meet their needs as significant to assess. They also emphasized the importance of research result novelty as a quality-assessment tool.

Research producers expect financial performance of research results as an assessment of the quality. They stressed the importance of funded research to show a return value to industry that is balanced. Academic standards is another aspect that research producers assume research users use to assess the quality of research results. Research producers consider that the quality of research results is associated with the quality of journal that the research results are published in and peer review of the research results. They also considered funding success as an important measure to assess the quality of research results.

Research users indicated assessing the quality of research results through scientific methods, research utilization, closeness to industry, financial performance, and academic standards. In terms of assessing the quality of research results through scientific methods, research users emphasized the importance of accuracy, where they expect the research

results to be repeatable and consistent constant. A research user stated, *"Data must be repeatable with several trials and show high precision" RU#2.* They also considered the importance of using a scientific basis for producing research results. Another aspect that is used to assess the quality of research results is research utilization. Research users highlighted the importance of demonstrable research results. They also considered the scalability and applicability of research results as important factors to assess the quality of research results. Research users also indicated the importance of closeness to industry to assess the quality of research results. They emphasized the need for effective research results to address issues related to biofuels. Research users implied the significance of research results to provide information on the costs of required material for implementation and the investment return with a clear timeline of investment. They also considered the significance of research results to be published as well as peer reviewed.

Summary

The analysis of this dimension indicated that research users and research producers identified similar aspects related to the compatibility of research results. These similarities consist of the importance of assessing the compatibility of research results depending on several aspects related to scientific methods, research utilization, closeness to industry, financial performance and academic standards. In terms of scientific methods, research users and research producers considered the scientific basis of research results and the accuracy of result as important matters. Both groups of participants emphasized the importance of research utilization to be applied and scalable in order to assess the quality of research results. They also gave attention to the importance of research results to be close to industry to address issues related to research users needs. Financial performance was taken into

consideration in order to provide information on the return on investment. Research users and research producers highlighted the importance of publishing and peer reviewing research results.

Although participants revealed similar perceptions, some differences can be distinguished in their responses. For instance, research users emphasized the importance of the accuracy of research results, but research producers did not. Only research users highlighted the importance of demonstrating research results. On the other hand, research producers emphasized the importance of scientific rigor. They also considered the importance of research producer reputation as an important factor to assess quality of research results. Research producers indicated the importance of novelty in research results as an assessment of research result quality.

Several studies showed that research users assess the effectiveness and quality of research results through publications, patents and spinoffs (Dechenaux et al., 2008; Nelson, 2012). However, the findings of this study suggested that research users assess the quality of research results through publications only, leaving patents and spinoffs not considered as an assessment measure of the quality of research results or any other dimensions. Moreover, according to the analysis of research user perspectives, there are several aspects that can be regarded to assess the quality of research results in addition to publications, such as scientific rigor in the development of research results and their effectiveness in addressing issues. For example, research users indicated that they assess the quality of research results through the scientific methods used in the development of research results. These aspects are regarded as a sub-dimension of quality in research results where it was mentioned only

as an assessment of the quality of research results, which was not considered as an assessment by the other dimensions such as usefulness or ease of use.

Chapter 6: Discussion

As shown in the previous two chapters, the questionnaire design of this study involved the use of both open-ended and structured questions to ensure that we covered all the relevant aspects to fulfill the aim of the study. The study asked general open-ended questions before the structured questions to avoid leading participants' responses to the questions.

This chapter presents a cross-case analysis of the findings from the open-ended and the structured questions. It will contextualize the finding that was analyzed in the previous two chapters. The chapter will be divided into three subsections. The first will discuss the uses of the research results. The second will examine the usefulness of the research results. The third will provide a general discussion of the findings.

6.1 The Uses of Research Results

Based on the analysis of the open-ended question and the structured question regarding the uses of research results, the responses of research users to both types of questions revealed the importance of using research results for cost reduction. For instance, research users emphasized the use of research results in the open-ended question, and they rated cost reduction the highest in the structured question. Research users' perception differs than research producers' expectations in the open-ended and structured questions regarding cost reduction. This finding should indicate the importance of using research results for cost reduction either for production development or for R&D. Both groups of participants disclosed similar aspects in their responses to the structured question, such as the use of research results for policy decisions and suggestions for future research or projects. On the

other hand, the responses to the open-ended question did not consider the use of research results to assist in problem solving and to reduce the time required for R&D projects.

The findings are consistent with several studies that emphasized the motives of university–industry interaction (Arvantities et al., 2008; Broström, 2012; Lee, 2000). The present study suggests the importance of collaboration, cost reduction, risk reduction, development and commercialization. In terms of cost reduction, research users may seek to use research results to reduce costs associated with product development and internal R&D. According to Han and Lee (2013), organizations or firms seek to collaborate with universities to reduce costs. This study emphasizes this aspect, although only research users emphasized the importance of cost reduction as one of the uses of research results. Both groups of participants emphasized collaboration.

Research on the importance of channels for accessing research results indicated that publication, direct communication and conferences are the most important (Cohen et al., 2002). The findings of this study confirm this result, indicating that the two most used channels to access research results from the perspectives of research users and research producers are academic journal articles and direct communication with researchers. This study also confirmed the importance of journal articles as a channel for accessing research results (Gonzalez-Brambila & Veloso, 2007). However, academic conferences did not receive as much attention as academic journal articles and direct communication with researchers.

According to Bekkers and Bodas Freitas (2008), the relative importance of different channels of interaction is similar between research users and research producers. However, academic researchers assign greater importance to some channels than research users do.

This study confirms that, even though there are some similarities between researchers and research users in rating the access channels, research producers give more attention to academic journal articles.

6.2 The Usefulness of Research Results

Asking participants about their perception of useful research results indicated four main categories: (a) financial assessment, (b) technical issues, (c) societal issues, and (d) transfer processes. These categories are considered the main concerns within the advanced biofuel industry. Within these categories, the present study finding is consistent with the three main factors that drive sustainability for the biofuel sector that was identified by Speight and Singh (2014) which are economic, social, and environmental sustainability. From the economic perspective, biofuel production requires cost effectiveness and competitiveness. It requires generating a substantial new demand in the agricultural economy from the social perspective and reducing the stress biofuels impose on natural ecosystems from the environmental perspective (Curran, 2012; Speight & Singh, 2014). Additionally, the biofuel sector has financial and commercial risks (Sims et al., 2010). The ability of research results to provide information to reduce risks associated with advanced biofuels is one of the important and useful aspects of research results identified within the biofuel sector.

Based on the analysis of the open-ended question and the structured questions, there is a considerable overlap between the revealed perceptions in the questions. However, the structured questions provided more specific assessments of the usefulness of research results. Only one aspect that was covered in the responses to the open-ended question was not considered in the responses to the structured questions: risk reduction. This aspect was

identified in the context of preventing any risks associated with the implementation of research results as well as any risks of commercializing the produced products.

The literature showed that the essential purpose of research users collaborating with a university is to obtain research results that can be used to solve problems, reduce costs, and enhance economic development (Perkmann et al., 2011). These are considered the main drivers of university–industry collaboration, and these aspects can be used to assess the output of the university. The analysis of the study found that problem solving, cost reduction, and economic development are aspects that make research results useful. For example, research users revealed that the ability to use research results to solve a problem would enhance their status, relative advantage, and the quality of using research results when they considered economic development as an aspect to enhance their relative advantage. Cost reduction in production processes is another example that is used to assess the usefulness of research results and relative advantage.

Several studies showed that research users assess the effectiveness and quality of research results through publication, patenting and spin-offs (Dechenaux et al., 2008; Nelson, 2012). However, the findings of this study suggested that research users in the biofuel sector assess the quality of research results through publication and do not consider patenting and spin-offs as an assessment measure of the quality of research results or any other dimensions. Moreover, according to the analysis of research users' perspectives, several aspects can be regarded to assess the quality of research results in addition to publication, such as the use of scientific rigor in the development of research results and the effectiveness of results in addressing issues. For example, research users indicated that they assess the quality of research results through the scientific methods used in the development of research results.

These aspects are regarded as sub-dimensions of research result quality; they were mentioned only as an assessment of the quality of research results and were not considered as an assessment by the other dimensions, such as usefulness or ease of use.

This study followed a unique approach in employing the characteristics of innovation to the context of assessing research results. These characteristics were used in the adoption of products or services that were still in the development stage.

According to Rogers (2003), the characteristics of innovation can be used in many studies, depending on a study's context, which indicates that each field of study can implement these dimensions to fit the aim of the study. For example, previous studies used these characteristics to investigate the obstacles to adopting mobile banking services (Cruz et al., 2010), the acceptance of Internet services (Rokhman, 2011), the aspects that influence customers to use e-commerce (Johar & Awalluddin, 2011), and the tools used by instructors in higher education (Schoonenboom, 2014). Members of each field used their own approaches to achieve their aims but used similar perceptions, which makes it easy to compare the findings of their studies. From the perspective of the DoI literature, Rogers (2003)indicated that the characteristic of innovation used to assess the perception of individuals to adopt an innovation are articulated differently depending the context of the study under investigation. From this perspective, it is difficult to compare the current study's findings with those of previous studies that used the same characteristics.

In terms of assessing research results, several studies used different assessments of research results, including patenting, publication and licensing (e.g., Dechenaux et al., 2008; Thursby et al., 2001). These studies assessed and evaluated research results that were already commercialized, which is not the case of the study under investigation. This study focuses on

research results that are still in the early stage of development, which assumes that a similar perception of the characteristics of innovation can be employed in the context of research results.

The employed characteristics of innovation did reveal applicability to the context of research results. However, applicability depends on whether the characteristics can be used to describe different assessments of research results. Each of those characteristics of innovation was applicable when defining different sets of assessment criteria that are used to assess research results.

Thus, this study employs dimensions that are used in the innovation adoption models to identify the characteristics that assess research results. The following dimensions are proposed to assess the research results on several scales: (a) usefulness, (b) ease of use, (c) relative advantage, (d) compatibility, (e) status, and (f) quality. Each of these assessment dimensions can identify several aspects regarding research results from the perspectives of research users and research producers.

The findings of this study suggest that each one of the characteristics of innovation used to assess research results consists of sub-dimensions. The dimensions used in this study draw on assessing the usefulness, ease of use, compatibility, relative advantage, status, and quality of research results. Table 14 presents the sub-dimensions identified in this study.

Table 15 Measures of Key Aspects Related to the Adoption of Research Results

Characteristics	Measurement of the Characteristics
Usefulness	Financial assessment Time to market Scalability Ease of implementation Communication between researchers and research users Originality of the research results Accuracy of the research results Relevance
Ease of Use	Financial assessment Documentation and reporting Relevance of the research results Project management Scalability
Relative Advantage	Financial assessment Production improvement Novelty Solves a problem Policy contribution Reputation of researchers Scalability
Compatibility	Analysis model Project management Scalability Sustainability Technology infrastructure Financial assessment Demand requirement
Status	Financial assessment Relevance Increase R&D capacity Reliability of results Publication Patent Commercialization records Industry recognition Government involvement
Quality	Scientific methods Scalability Reputation of researchers Novelty Solve problems Publication Peer review Journal's level Level of funding

Comparing the findings of the open-ended question about what makes research results useful and the structure-question about the assessment criteria of the characteristics of useful research results indicates that the respondents were able to distinguish the differences between the two types of questions. Their perceptions in both types of questions identified different concepts. For instance, the open-ended question provided a bigger picture of useful research results in term of issues related to financial performance, technical and social issues, and communication between research users and research producers. On the other hand, the responses of the structured question provided more detailed assessment of research results with the use of DoI, PCI and TAM frameworks dimensions. Each of the used dimensions was able to provide detailed assessment of useful research results. For example assessing useful research results in term of its relative advantage to research users, the findings of the study suggested that research results needs to provide technical aspects, have policy contribution, provide financial assessment and high reputation of the researchers. Table 16 provides the assessment of all the dimensions and the assessment criteria of each dimension.

The study found that the driven dimensions from the DoI, TAM and PCI models can be applied to the context of research results by adding an additional dimension of technological risk reduction. The study suggests that these dimensions are able to identify several aspects regarding the usefulness of research results. From the perspective of the literature on technology transfer, the assessment measures that are used to assess research outputs are publication, licensing, spin-offs and patenting. However, this study identifies several scales that can be used to assess research outputs such as usefulness, ease of use, compatibility and quality. For example, to assess the ease of use of research results, several assessment criteria are used, such as documentation and reporting, scalability and relevance

of research results. The measures of the characteristics of innovation should be exclusively formed in each study. In the context of the healthcare sector, for example, several studies used DoI, PCI and TAM. As a result, it is possible to compare the findings within the same sector. However, in the context of research results, there are no previous studies that used these models. It was difficult to compare the findings with other studies as this study explores characteristics of early-stage research results that have not been identified before.

Chapter 7: Conclusion

7.1 Summary

Universities play an important role in improving the development of science and technology, and the commercialization of their discoveries plays important role in enhancing economic growth and technological change. Universities discoveries encourage the collaboration between universities and industry in order to improve use of research results. For example, as discussed here, biofuel organizations may use research results to facilitate the development of biofuels—for various reasons. These organizations may require different types of information to direct their decision making, to meet a range of other requirements they need and to achieve their objectives. Therefore, research activities play an important role in the collaboration process between university and industry.

This study identifies the specific characteristics of advanced biofuels research results that are not yet commercialized. It also employs a qualitative embedded single-case study research methodology and relies on dimensions of the DoI, PCI and TAM frameworks. Semi-structured interviews were conducted with 22 research users and research producers. The data were collected at the World Congress on Industrial Biofuels and the Annual General Meeting of BioFuelNet, a network that brings together the Canadian biofuels research community. The analysis of the interviews involved within-group content analysis, which employed coding and categorizing the obtained responses. The analysis also involved comparison of the similarities and differences between the two groups of participants.

The advanced biofuel sector is used as a case in the current study because this sector provided a great example to establish our framework. This sector requires considerable

research effort in order to assist stakeholders in enhancing the production and commercialization process as well as improving several technical issues related to advanced biofuels. As this study demonstrates, this sector has proven itself to be a good case study for identifying the characteristics that assess research results.

This study addresses three research questions. The first question was what characteristics make research results useful for biofuel research users in order to articulate their needs? In order to answer this question, the present study used dimensions from DOI, PCI and TAM frameworks: usefulness, ease of use, compatibility, relative advantage, Status and quality. Each of these dimensions identified several assessments of research results that make research results useful in order to articulate research users' needs. The second research question is can DoI, PCI and TAM frameworks be applied in the context of research results? The findings of this study found that DoI, PCI and TAM frameworks can be applied into the context of research results due to their ability to identify several assessments of research results. The third research question is do these models adequately cover all the dimensions of early-stage research results? These models showed their applicability into the context of research results with adding an additional dimension of technological risk reduction.

The findings of the current study shed light on the identification of the characteristics that are used to assess research results for advanced biofuel research users. The framework identified in this study adds to the existing body of research on the assessment of early-stage research results. It presents the applicability of the characteristics of innovation dimensions derived from DoI, PCI and TAM into the context of non-commercialized research results. Each dimension from these frameworks identified several assessment criteria that are perceived by research users and research producers.

7.2 Contribution

As mentioned earlier, this study identified the characteristics of research results that benefit biofuel research users to meet their requirements and facilitate policy decisions from the perspective of research producers and research users.

From a theoretical perspective, the study demonstrates the relevance of the employed dimensions from DoI, PCI and TAM into the context of research results. It implies that these dimensions are applicable with this addition of an extra dimension: risk reduction.

From a research management perspective, the findings of this study have a practical implication: to enhance the collaboration between academic researchers and research users, which will facilitate the process of technology transfer and commercialization. Such collaboration is assumed to reduce the gap between research and its application.

The finding of this study adds to the literature assessment of research results that is in its early-stage development which was not established before. It assists researchers to better understand their users' perspectives in constructing the design of their research. Also it helps researchers to assess research users needs of research results from different perspectives with the use of the established framework in this study which is assumed to simplify the complexity of research use. Moreover, the improvement of the linkage between researchers and numerous research users will provide research users with appropriate information for policy decisions and business problems related to advanced biofuels.

The finding of this study is also assumed to tailor research results to research users' need which is assumed to improve the uptake and development of research results with the realization of sustained collaboration between scientific knowledge producers and users. This

will not only permit the push of scientific research results to research users only put also permit research users to inform research needs.

7.3 Limitations

The present study has limitations. The narrow focus on biofuels reduces the generalizability of the findings of this study to other contexts. The results document the perceptions of advanced biofuel research users and research producers, but what is applicable for this group might not be applicable to another group from another sector. Another limitation of this study is that the lack of external validity due to its exploratory nature. This study is also limited by the number of dimensions employed, in that the study eliminated two dimensions from DoI and PCI. These two dimensions could have added useful insights.

7.4 Future work

For quantitative investigation, larger sample sizes will be required to ascertain the degree of impact that these dimensions have on the assessment of research results. Further studies are needed to examine the needs of research result users for different types of research users in the field. Future studies should examine the applicability of the identified assessment criteria to other fields of study and to validate the finding of this study. Even though this study considered different channels for accessing research results, future research needs to consider more formal and informal mechanisms of accessing research results and address the influence of these channels on the criteria for assessing early-stage research results. Future work needs to include the eliminated dimensions and examine their applicability in the context of research results assessment.

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Appendix A

Author	Year	Journal	Title	Focus
(Johnson et al., 2013)	2013	*Journal of Environmental Management*	Advancing Sustainable Bioenergy: Evolving Stakeholder Interests and the Relevance of Research	How stakeholder participation in research can increase the relevance of its products?
(Roelofsen et al., 2011)	2011	*Research Policy*	Stakeholder interaction within research consortia on emerging technologies: Learning how and what?	Address the current lack of attention for multi-stakeholder involvement in large-scale research collaboration, and offer practitioners building blocks for designing multi-stakeholder dialogues.
(Jolibert & Wesselink, 2012)	2012	*Environmental Science & Policy*	Research impacts and impact on research in biodiversity conservation: The influence of stakeholder engagement	How does stakeholder engagement in biodiversity research foster its impacts to support learning on sustainability?
(Driessen & Hillebrand, 2013)	*2013*	*Journal of Product Innovation Management*	Integrating multiple stakeholder issues in new product development: an exploration	What stakeholder integration entails in the context of complex arena of multiple and conflicting stakeholder issues
(Mackinson et al., 2011)	*2011*	*Marine Policy*	Engaging stakeholders in fisheries and marine research	How can a deeper and more systematic engagement of stakeholders be enabled through European research activities?
(Phillipson et al., 2012)	2012	*Environmental management*	Stakeholder engagement and knowledge exchange in environmental research	how are stakeholders involved in research projects? What is the ongoing perceived impact of the engagement, both on the research process and on the stakeholders' knowledge and practices?

Author	Year	Journal	Topic	Focus of the study
Adams, Fontana & Malerba	2013	Research Policy	The magnitude of innovation by demand in a sectorial system: The role of industrial users in semiconductors	What extent of total innovations is developed by demand? What differences exist across various types and categories of demand? Does the magnitude of innovation by demand change over time?
Asakawa, Nakamura, & Sawada	2010	R&D Management	Firms' open innovation policies, laboratories' external collaborations, and laboratories' R&D performance	Investigate the impact of firm- level open innovation policy and laboratory-level external collaborations on different types of R&D performances at the laboratory level
Muscio, Quaglione & Vallanti	2013	Research Policy	Does government funding complement or substitute private research funding to universities?	Investigate the effects that government funding for academic research activity has on the external funding to universities raised through research contracts and consultancies.
Perkmann, Neely & Walsh	2011	R&D Management	How should firms evaluate success in university–industry alliances? A performance measurement system	proposing a 'balanced' performance measurement system for university–industry alliances
Fuentes & Dutrénit	2012	Research Policy	Best channels of academia–industry interaction for long-term benefit	Identify the effect of drivers to collaborate on channels of interaction and the effect of these channels on the perceived benefits of interaction.
Phillipson, Lowe, Proctor & Ruto	2012	Environmental management	Stakeholder engagement and knowledge exchange in environmental research	how are stakeholders involved in research projects? what is the ongoing perceived impact of the engagement, both on the research process and on the stakeholders' knowledge and practices?
Freitas et al	2013	Research Policy	Finding the right partners: Institutional and personal modes of governance of university–industry interactions	Examine the characteristics and strategies of firms that interact with universities under different governance modes

Empirical studies of TAM

Field	Studies	Focus
IT	(Gefen & Straub, 1997)	The effect of Gender on TAM
	(Mah et al., 2011)	Investigating the acceptance of m-CV
Health Care	(Holden & Karsh, 2010)	Examining the applicability of TAM theory for health care
	(Gagnon et al., 2012)	The Examination of factors influencing the decision of using a telemonitoring system by healthcare professional.
	(Kowitlawakul, 2011)	The Determination of factors that influence nurses' intention to use the eICU technology
E-Commerce	(Johar & Awalluddin, 2011)	The contribution of TAM in e-commerce acceptance
E-Government	(Shyu & Huang, 2011)	The investigation of the factors influencing e-government learning acceptance
	(Shareef et al., 2011)	Determine the critical factors influencing the adoption of e-government at different stages services maturity.
	(Lee et al., 2011)	The adoption of an online tax filing service by business users
Education	(Schoonenboom, 2014)	The explanation of different tools used within learning management systems (LMSs) by instructors in higher education.
	(Edmunds et al., 2012)	Explore technology acceptance through a comparison of work, study and leisure contexts
	(S. Y. Park et al., 2012)	The development of a general linear structural model of m-learning acceptance of university students.
	(Cheng et al., 2013)	Investigation of the acceptance of technology applying digital game- based learning to environmental education
Product adoption	(Broman Toft et al., 2014)	The acceptance of smart grid technology
	(E. Park et al., 2014)	Investigating the drivers adoption of car navigation systems

PCI Examples

Field	Studies	Focus
Information Technology	(Cruz et al., 2010)	Perceived obstacles to the adoption of mobile banking services among Brazilian internet users
	(D. A. Adams et al., 1992; Perez, 2013)	Factors influencing adoption of information systems in the medical education sector
E-commerce	(Poong et al., 2009)	A framework to explain business-to-consumer e-commerce adoption among Malaysian consumers
	(Andrews & Bianchi, 2013)	Factors that influence the purchasing behavior of Internet consumers
E-government	(Rokhman, 2011)	Acceptance of Indonesian Internet users to e-government services in terms of relative advantage, image, compatibility and ease of use variables
	(Hussein et al., 2011)	Factors influencing the intentions of citizens to use e-filing in the Malaysian context.
	(Carter & Belanger, 2004)	Factors that influence citizen adoption of e-government initiatives

Appendix B: Consent Form

CONSENT FORM TO PARTICIPATE IN RESEARCH PROJECT

Project Title: Characteristics of biofuel research results

Conducted by:
Prof. Sandra Schillo, Telfer School of Management, University of Ottawa
Enas Alhassan, Masters in Systems Science student, University of Ottawa

Invitation to participate: I am invited to participate in the aforementioned research study conducted by Enas Alhassan and Prof. Sandra Schillo because I am an actual or potential user or producer of biofuel research. This data will also be used for a Masters' thesis.

Purpose of the Study: The purpose of the study is to identify characteristics that users and producers of biofuels research deem important to effective use of the research results. The researchers will examine whether the perspectives are the same for producers and users of the research, as well as for different types of users, such as users from industry, policy, or public research communities.

Participation: My participation consists in being the respondent in a 10 minute semi-structured interview. The interview will be scheduled during the 2013 World Congress on Industrial Biotechnology or the 2013 BioFuelNet Annual General Meeting and/or at a date/time that is convenient to me. If I agree, I may possibly be asked to participate in a very brief follow-up interview as well, if there is a need to clarify any responses from the initial interview.

Benefits: The main benefits of participation in this study will include (1) An opportunity for the academic community to learn about the useful characteristics of research results; (2) A preliminary set of characteristics of research results that may make research more usable.

Risks: I have reviewed this consent form with _____ and she has reassured me that my participation in this study will involve no foreseeable risk other than those encountered in everyday life.

Confidentiality and anonymity: I have received assurance from _____ that the information I will share will remain strictly confidential. I understand that the contents will be used only to develop concepts and frameworks relating to the use of research results, and that all personally identifying information will be removed and the contents of any quotes used (in either the technical report to participants or in any subsequent published research) will not be revelatory of my individual identity.

Optional audio recording: I agree / do NOT agree to have my responses captured with a digital audio recorder. I understand this choice is entirely optional, and the recording will serve the sole purpose of ensuring my contributions are adequately captured by the researchers.

Review of responses: I am requesting that _____ will / will not forward a transcript of the interview to me for (a) my verification in regard to the accuracy of its content, and (b) in order to enable me to indicate to any specific self-identifying information that I would rather she not share. If I request to receive a transcript, it will be forwarded to me by regular email and I have been informed by _____ of risks relating to computer security. I will then have the opportunity to a) make amendments to the information provided during the interview, or to withdraw the data from the study and have all my responses deleted, and/or b) request that any self-identifying information be removed. I can do so by way of an email notification to _____.

Conservation of data: All transcripts will be kept in Prof. Schillo's office, which is located on the uOttawa campus. The office is always locked when she is not in it. Moreover, within her office, the data will be kept within her locked filing cabinet. After a period of 7 years after the completion of the project, the transcripts will be shredded and the digital interview recordings will be deleted.

Voluntary Participation: I am under no obligation to participate, and if I choose to participate, I can withdraw from the study at any time and/or refuse to answer any questions, without suffering any negative consequences. Moreover, should I decide to withdraw or refuse to participate to any extent, I understand that (a) this decision will be kept strictly confidential; and (b) all data gathered from me until the time of withdrawal will be destroyed upon my request.

Acceptance: I, _____, agree to participate in the above research study conducted by Enas Alhassan and Prof. Sandra Schillo of the Telfer School of Management.

Participant's signature: _____ Date: _____

Researcher's signature: _____ Date: _____

Appendix C: Questionnaire

QUESTIONNAIRE FOR RESEARCH PROJECT

Your Name: _____

Name of your organization: _____

Job Title: _____

1) In what function are you attending this conference?

☐ Industry representative ☐ Publicly funded researcher ☐ Policy developer / regulator

☐ Investor ☐ Funder (public sector)

Other, please specify:

2) What are your key interests (circle all that apply)?

Type of biofuel: (other – please specify: _____)

biodiesel bioalcohol biogas

Type of Feedstock: (other – please specify: _____)

soybeans corn wheat sugarcane cellulosic feedstocks algae

Value Chain: (other – please specify: _____)

feedstock development conversion utilisation

3) Research users: Please describe how you typically use research results.
Research producers:
Please describe what uses/by whom you anticipate when you produce research results.

4) In your opinion, and for your use (the anticipated use) what makes biofuel research results useful?

We have identified some items with regards to uses and characteristics of research results that have received attention in the academic literature.
We would appreciate your feedback on whether – in your experience with biofuel research results – these items are relevant to research users like yourself / the research users you intend to reach

5) When you use research results / when your users access your research results, how likely are they going to be using the research results for the following purposes?

Scale: 1 = extremely **un**likely … 7 = Extremely likely	
Improve fundamental understanding of phenomena	①-②-③-④-⑤-⑥-⑦
Assistance in problem solving	①-②-③-④-⑤-⑥-⑦
Source of information suggesting new projects	①-②-③-④-⑤-⑥-⑦
Policy decision	①-②-③-④-⑤-⑥-⑦
Cost reduction in product or process development	①-②-③-④-⑤-⑥-⑦
Reducing the time required for completion of company's R&D projects	①-②-③-④-⑤-⑥-⑦

Other:

6a) How do you assess **how useful** certain biofuel research results are going to be? What characteristics make research outputs useful to you / the intended users?

6b) What criteria do you use to assess how **easy to use** new biofuels research results are going to be?

6c) What criteria do you use to assess whether they have a **relative advantage** over research results you have previously known about? What does relative advantage mean to you?

6d) What criteria do you use to assess whether biofuels research results are **compatible** with your/your intended users' existing technologies or frameworks?

6e) How do you assess whether using specific biofuels research results would enhance your **status or respectability (credibility)** ?

6f) What criteria do you use to assess the **quality of** research results?

7) How well do biofuels research results you are familiar with meet your / your intended users' criteria in your experience?

Research results meet these criteria: 1=never ①-②-③-④-⑤-⑥-⑦ 7= always

Please elaborate:

8) In what area are research results most likely to fall short in terms of their usefulness to you?

9a) Research users: Please indicate how you assess the mechanism of accessing research results.
Research producers: Please make the best guesses possible as to how your intended users might consider these mechanism.
Please rank each item on a scale of 1 to 7.

Source	Ease of Access	Salience (Relevance)	Legitimacy	Credibility	Frequency of Access
Academic Conferences					
Academic Journal Articles					
Academic Books					
Direct communication with researchers					

9b) Does the above reasonably reflect your pattern of access to research results? ☐ Yes ☐ No

If not: Why not? What is missing?

10) Which statement best describes your / your intended users' access to research results?

☐ If I need access to research I will do what it takes to get access to it

☐ I have sufficient resources (time, money) to access all the research results I need

☐ If I had easier access to research outputs, I would be able to use them more extensively

May we follow up with you if we have any additional questions? ☐ Yes ☐ No

Would you like to see a copy of your responses? ☐ Yes ☐ No

If yes, please provide the email address to which we can send the material:

_____

Appendix D: Interview Respondents

Interviewee ID	Interviewee Type
1	Research Producer
2	Research Producer
3	Research Producer
4	Research Producer
5	Research User
6	Research User
7	Research User
8	Research User
9	Research Producer
10	Research Producer
11	Research Producer
12	Research User
13	Research User
14	Research User
15	Research User
16	Research User
17	Research User
18	Research Producer
19	Research Producer
20	Research Producer
21	Research Producer
22	Research Producer

Appendix E: Coding

E.1 Use of research results

Category	Code
Research focus	Future research
	Publication
	Validation of internal research
Decision Support	Feasibility assessment
	Feedstock planting decisions.
	Project assessment.
	Risk assessment
Public outcome	Consumer protection.
	Public education.
	Policy development
Partnering	Collaboration
Development and Commercialization	Testing for Commercialization
	Development of new/improved feedstock
	Development of improved processing methods
	Technology development
	Meet demand-side BF specification
	Commercialize new/Improved product
Financial assessment	Cost reduction

E.2 The usefulness of research results

E.2.1 Open-ended question

Category	Code	Frequency of code	
		RP	**RU**
Financial assessment	Cost reduction	3	5
	Risk reduction	1	2
	Economic feasibility assessment	3	1
Technical Issues	Technical needs	3	3
	Compatibility	3	2
	Scalability	1	1
	Improvements	2	0
Society	Sustainability	1	1
	Impact assessment	2	1
	Social Issues	2	0
Transfer Process	Communication	1	1

E.2.2 Structured-question: The TAM/PCI Models measurement tools

TAM/PCI	Category
Usefulness	Technology Development
	Financial performance
	Collaboration process
	Quality
	Originality
	Relevance
Ease of use	Financial performance
	Transformation process
	Implementation
Relative advantage	Financial performance
	Technical improvement
	Closeness to industry
	Policy contribution
	Reputation of the researchers
Compatibility	Financial performance
	Technical development
	Project analysis framework
	Demand framework
Statues	Financial performance
	Closeness to industry
	Quality
	Commercialization development
	Recognition
Quality	Scientific Method
	Applied nature of research
	Reputation
	Closeness to industry
	Financial performance
	Academic Standers

E.2.2.1 Usefulness

Category	Code	Frequency of code	
		RP	RU
Financial performance	Cost reduction	4	1
Technical development	Compatibility	1	0
	Scalability	1	1
	Time to market	0	1
	Ease of implementation	2	0
Quality	Accuracy	3	2
	Replicability	0	1
Collaboration Process	Communication	2	1
	Project management	0	1
Originality	Patentable	1	0
	Innovativeness	3	0
Relevance	Relevance	5	1

E.2.2.2 Ease of Use

Category	Code	Frequency of code	
		RP	RU
Financial performance	Cost reduction	2	0
Transformation process	General reporting	0	3
	Documentation form	2	2
	Project management	1	0
Implementation	Relevance	1	1
	Fit with capacity	3	1
	Scalability	1	1

E.2.2.3 Relative Advantage

Category	Code	Frequency of code	
		RP	RU
Financial performance	Cost reduction	4	2
Technical improvement	Production Improvement	1	0
	Accuracy, Improve quality, better results	1	0
	Novelty	1	0
	Facilitate feedstock streams	1	0
Closeness to industry	Scalability	0	1
	Useful	0	1
	Difficult to use	0	1
	Solve problem	1	2
Policy contribution	Economic impact assessment	2	1
	Macro/policy contribution	1	0
Reputation of the researchers	Researchers Reputation	1	0
	Level of fund	1	0

E.2.2.4 Compatibility

Category	Code	Frequency of code	
		RP	RU
Project Analysis framework	Analytical models	2	0
	Canadian policy needs	1	0
	Project management	1	0
Technical development	Sustainable	0	1
	Scalable	0	1
	Technology infrastructure	3	3
Financial performance	Cost expectation	1	1
Demand framework	Costumer request	2	2
	User-specific	1	0
	Available feedstock	0	1

E.2.2.5 Status

Category	Code	Frequency of code	
		RP	RU
Financial assessment	Profit Increase	1	0
Technical Aspects	Relevance	0	1
	Demand for service	0	1
	Value added to partner	1	1
	Address gaps.	1	1
Research association	Increase R&D capacity	0	1
	Association with professor	1	2
Research Value	Quality of data/results	2	4
	Reliability of results	5	1
	Novelty	0	1
Commercialization development	Quality of publication	0	1
	Patenting	0	1
	Commercialization track record.	0	1
Recognition	Government involvement	0	1
	Industry recognition	0	2
	Neutral party status	0	1

E.2.2.6 Quality

Quality	Code	Frequency of code	
		RP	RU
Scientific method	Scientific rigor	5	3
	Result examination	2	0
Results utilization	Applied	1	1
	Can be demonstrated	0	2
	Scalability	1	2
Reputation	Industry recognition	1	0
	Reputation	1	0
	Media coverage	1	0
Closeness to industry	Novelty	2	0
	Effectiveness in addressing problems	2	2
Financial performance	Value for money	1	1
	Value added to partner	2	0
Academic Standard	Publication quality	6	2
	Success with funding	1	0