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TECHNOLOGY DEVELOPMENT PRACTICE IN ETHIOPIAN SCIENCE AND TECHNOLOGY UNIVERSITIES

Analyzing the Actors and Management

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ABSTRACT

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Higher education institutions are increasingly embracing the third mission of connecting with broader society, primarily through technology transfer. Ethiopia established two Science and Technology (S & T) universities in 2015 with the specific mission of developing and disseminating technology supporting the country's economic development agenda toward industrialization. Thus far, research findings indicate that the effectiveness and challenges of such university-based technology development and transfer programs are explained by context-based practices. Universities with the same mission in developing countries faced various internal management challenges requiring context-based research. Given the mission's fledgling state, this paper examined technology development within the two S&T universities. As such, the purpose of this study was to identify the actors involved in technology development process, evaluate their relationships, analyze their impact on the outcome, and propose solutions to identified gaps.

The study's theoretical underpinning is agency theory, and organizational control theory is used to complement it. The two S & T universities' technology development processes are centered on prototype development. Hence, the study was conducted based on the practices in technology development projects since 2015. Interviews and document reviews were conducted to collect detailed information in context, and conclusions were drawn using thematic analysis. According to the findings, two national ministries oversee universities' technology development programs: the Ministry of Science and Higher Education (MoSHE) and the Ministry of Finance (MoF). The former oversees operational performance, while the latter directs budget utilization in all university programs, including technology development. Similar structures and roles are reflected in the technology development process within universities. While the finance and procurement directorates are responsible for enforcing MoF's rules and regulations, the Technology Transfer Offices (TTOs) manage the technology development program. The contract, between TTOs as principals and technology developers as agents, incorporates outcome-based contracts for evaluating developed technologies and behavior-based contracts for controlling the budget expenditure. Consequently, compliance with finance and procurement rules and regulations takes precedence, resulting in outcome uncertainties in the technology development process. Gaps in technical knowledge and skills during the technology development add to the outcome uncertainties. These outcome uncertainties slowed projects' progress, adversely affected the output targets, complicated the execution of outcome-based contracts, and caused TTOs to deviate from the shared technology development goals. The solution forwarded is a change in the mandate of actors overseeing the technology development and budget utilization. Thus, first, both the technology development performance and budget utilization oversight mandate should be put under the auspices of a single entity at national level and replicate this arrangement under the mandate of TTOs'. The goal of this solution is mitigating the outcome uncertainties. Second, TTOs should introduce clan socialization during the technology development process to close knowledge and skill gaps and foster a support system for technology developers. Finally, the paper discusses the practical and theoretical implications of the study.

Keywords: technology development, science and technology universities, outcome uncertainty, agency theory

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Chapter One: Introduction

1. Introduction

Along with teaching and research missions, higher education institutions have been incorporating a third mission. In many countries, the mission is driven by government-led policies and efforts (Marhl & Pausits, 2013). The third mission encompasses various components, including technology transfer, community service, and consulting (Berghaeuser & Hoelscher, 2020; Secundo et al., 2016; Marhl & Pausits, 2013), which are geared toward commercialization or community outreach (Hellström et al., 2013).

As it is the latest initiative, increased focus is being paid to national and institution-level studies that assess the third mission's components, challenges, and outcome effectiveness. Nonetheless, research gaps indicate further research needs on the third mission's internal management system, as studies so far focus primarily on the mission's outcome (Rubens et al., 2017; Rolfo & Finardi, 2014). This is because, first, the internal management system affects the outcome of the third mission (Stock & Tatikonda, 2000). Second, institutional upheavals are prevalent in developing countries' institutions and countries at nascent stages of adopting the third mission, as some studies have revealed (Ssebuwufu et al., 2012; Göransson et al., 2009). These challenges include an old institutional system that impedes the new mission and a scarcity of resources (Göransson et al., 2009).

Ethiopia is not an exception to these dynamics, and the country has enlisted universities to the third mission, most notably by creating two S&T universities as part of its industrialization-focused economic policy (MoFED, 2010; Oqubay & Ohno, 2019; Eckl et al., 2017). The third mission of the two S & T universities includes a variety of programs, including technology transfer. This study examines the technology transfer programs administered by universities' Technology Transfer Offices (TTOs). Nonetheless, the study is limited to the technology development process, as a preliminary assessment indicated shortcomings in achieving the projects' outcome. The study intends to contribute to literature and practice by spotlighting a university-based technology development system in a developing country and contextualizing challenges and solutions.

The study concentrated on the actors participating in the technology development process, their relationships, and the impact of those ties on the process's outcome. Despite the complexity of the relationships among university actors, the data collection, analysis, and conclusion scope are limited to technology development program. The study complemented agency theory with organizational control theory to develop a theoretical framework as a lens. The theories are applied both in higher education institutions (Kivistö, 2007a; Kivistö, 2005) and in the context of technology development in the same institutional setting (Johnson, 2011; Gulbrandsen, 2010). An agency theory explains relationship between actors cooperating to attain a particular task having differing goals and how the relationship is governed (Eisenhardt, 1989). As such, the study revealed distinctive practice features and recommended future actions to remedy identified gaps.

1.1.Background of the study

In order to spur growth and development in Ethiopia, two new Science and Technology (S&T) universities were founded at Adama city, Adama Science and Technology University (ASTU) and at Addis Ababa, Addis Ababa Science and Technology University (AASTU) in 2011 in line with the Growth and Transformation Plan (GTP) of 2010 (FDRE, 2010; MoFED, 2010). The two universities have been committed to research and technology development and transfer to industry and community (MoFED, 2010; Federal Ministry of Education, 2010; ASTU, n.d.-a). To this goal's end, a bilateral cooperation agreement with the South Korean government was entered to emulate the country's best S&T institutions and mobilize resources (Baumann & Lauberbach, 2019; Oqubay & Ohno, 2019; Eckl et al., 2017; Xinhua, 2019).

In 2014/15, the two universities got a special annual budget and adopted new structures and systems to support their specific new mission. Internally, the establishment of Centers of Excellence, Technology Transfer Offices (TTO), and Research Park were all intended to support their mission (Eckl et al., 2017). For example, the high-tech Aerospace Center of Excellence was established and led by the former South Korean Aerospace Research Institute president (ASTU, n.d-b). All these were indicators of the institutionalization process (Cai et al., 2015) of Ethiopian technology development and transfer efforts, among others, through the two S & T universities.

The universities went through a series of changes to take their current shape. ASTU had Social Science, Education, and Business academic programs when its name was changed from Adama University to ASTU in 2011 (ASTU, n.d.-a), which were excluded from academic programs in 2015 to focus on only S&T programs. AASTU was established as S&T University in 2011 with technology and engineering programs (AASTU, n.d-a). In 2014/2015, the Council of Ministers transferred the two universities from the former Ministry of Education (MoE) to the Ministry of Science and Technology (MoST), and they became purely S&T universities, with new science and engineering programs backed by resource mobilization from the government (Eckl et al., 2017). At the same time, the universities added organizational structures to accommodate Community Service and Technology Transfer programs (Eckl et al., 2017). In 2018, the government reassigned the two universities to the newly created Ministry of Science and Higher Education (MosHE), and their mission continued under the “specialized universities” category when the rest of the universities were categorized as research, comprehensive, and applied universities (Fana, 2020). After a decade of transition into S&T universities and five years of critical implementation of their technology development program, some gaps require investigation.

Based on the preliminary information collected, the two S&T universities, ASTU and AASTU, have encountered practical difficulties in handling technology development projects, including delays and interruptions. The two universities' national missions and the practical challenges were justifications for this study. Likewise, the same trend of internal hurdles has been facing African universities embracing technology transfer programs which justify additional research in the same institutional context.

With the growing involvement of universities in innovation and technology transfer in developing countries, there have been empirical studies, in a broader context, elaborating the unique features in developing countries (Göransson et al., 2009). Generally, university technology transfer programs in developing countries are nascent (Fadeyi et al., 2019; Alessandrini et al., 2013). Lower technical performance, shortage in financial resources (Ssebuwufu et al., 2012; Göransson et al., 2009), and project management-related problems, among others, are bottlenecks for the maturity of the technology transfer system in African universities (Ssebuwufu et al., 2012). Hence, Göransson et al. (2009) proposed "institutional level" and context-based solutions to each country's technology transfer-related problems in Africa (p.164). Fadeyi et al. (2019) advocated for research on African universities' technology outputs in relation to the "inputs" or resources mobilized from government or stakeholders (p.15). As such, this study is a context-based study on African universities' technology transfer efforts, by focusing on the technology development process.

The study used a theoretical framework as a lens. The main goal of using theory is to explicate a "phenomenon," warrant coherent "explanation," and enhance prediction (Ågerfalk, 2014, p.549). Agency theory[1] (Eisenhardt, 1989), by complementing it with Organizational Control theory, it was used to examine the internal actors, their relationship to the technology development process, and the impact on outcome in two S&T universities in Ethiopia. The study focused on defining the relationships among the actors involved in the technology development process of the two S&T universities. Since the government is the source of funds from its treasury (see appendix 2) for the universities, there are accountability requirements for the resource utilized, and technology development and transfer programs are not exceptions. Such a relationship between government and universities makes agency theory application viable (Kivistö 2005). Moreover, Anderson et al. (2007) identified actors, internal and external, that significantly impact the efficacy of technology

[1] The theory used in this study will be mostly referred to as Agency theory hereafter for simplicity.

transfer in their empirical study. Agency theory allows for a better separation of various actors' positions and how their relationships are organized (Rasmussen & Gulbrandsen, 2012), adding to the relevance of the theory for this study.

In sum, this research is useful for practical purposes. In developing courtiers, understanding individual universities' context is critical to making institutional setups work better for technology transfer (Fadeyi et al., 2019). The study systematically explores the two universities' internal technology development challenges by employing agency theory. This is because the research is conducted in a particular context[2] and is an institution-based study (Göransson et al., 2009). Moreover, this study could contribute to empirical study literature on technology development and transfer issues from developing countries' perspectives.

1.2. Statement of the problem

ASTU and AASTU have been establishing the structure and infrastructure deemed necessary for their unique mission. This was given more focus when the university moved to the MoST in 2015. This change enabled the universities to access significant increments in government budget allocation. For instance, a financial data record from the finance directorate office of ASTU shows the budget of ASTU for community service and technology transfer increased from seven million birr in 2014/15 to twenty-eight million in 2015/16 (See appendix 1). While carrying out this specific objective of technology transfer thus far, there are researchable gaps in the technology development process of the universities.

Research gaps were identified in this research. Research problems are derived from gaps and "agendas" mentioned in previous research works (Müller-Bloch & Kranz, 2015, p.4). For instance, Rubens et al. (2017) asserted that while there is a wealth of literature on the third mission's economic contribution, there is a dearth on the specific internal challenges faced by university administrations, staff, and departments in carrying out the mission. Hence, this research gap recognizes the context based institutional differences in implementing the third mission. Similarly, in the most extensively investigated topic of proposing a universal third mission ranking system, contextual factors, especially institutional disparities, have complicated the pursuit of a universal ranking system (Secundo et al., 2016). This supports the premise of institutional and country context diversity of practice in the third mission. Nonetheless, the third mission and technology

[2] The word "practice" was chosen for this paper's topic to indicate its focus on the context.

transfer literature emphasize on institutional-level performance and models rather than internal management methods (Rubens et al., 2017; Rolfo & Finardi, 2014).

In the technology transfer practice of developing countries' universities, this gap is more vivid. The infant stage of technology transfer and commercialization practice of developing countries (Fadeyi et al.,2019; Alessandrini et al., 2013) is marred by poor technical performance (Göransson et al., 2009), funding problems (Ssebuwufu et al., 2012; Göransson et al., 2009) and lack of project management skills (Ssebuwufu et al., 2012), which are related to institutions' internal problems. In countries like Russia "old legal system" impedes technology transfer from universities (Göransson et al., 2009, p.160). As a result, there is no general "best practice" that can be transferred from developed to developing countries, and each country should examine its environment and institutional capability for technology transfer (Göransson et al., 2009, p.164). This exploratory study was designed to analyze the technology transfer practice in Ethiopian S&T universities due to these assertions as research gaps.

A preliminary assessment in a study enables a researcher to enlarge the research topic and better understand the issue (Yin, 2011). According to preliminary information gathered, project delays and interruptions and a lack of actual technology transfer were the most significant difficulties facing technology development at the two S&T universities. It is critical to investigate this gap since efficient technology development and transfer[3] requires a lively internal management system (Stock & Tatikonda, 2000).

Meanwhile, Gulbrandsen (2010) researched a Norwegian S&T university that performed low in actual technology transfer using agency theory to investigate the problem from management, technology transfer office, and scientists'[4] relationship perspective. This shows that some parallels exist between problems identified by Gulbrandsen (2010) and the preliminary finding in the two S&T universities, but most likely with different magnitude and variation in details. However, this study will use Agency theory to scrutinize the problem like Gulbrandsen (2010) did. Hence, this research addresses the research gaps identified from relevant literature and the practical problems of the two S&T universities to contribute to the literature in African university-based technology transfer practices.

[3] In this paper's context, the study is limited to technology development, hence "technology transfer", when mentioned refers to the end goal of the technology development process in universities.
[4] The term academic staff, scientist, and technology developer is interchangeably used

1.3.Research objectives and research questions

Multiple studies and reports indicate that developing countries generally have immense internal challenges of technology transfer management (Fadeyi et al., 2019; Alessandrini et al., 2013; Göransson et al., 2009; Ssebuwufu et al., 2012). Moreover, they also assert the need to conduct context-based research and solution formulation for the problems. Accordingly, the study's research objective is to explore the technology development process, the actors[5] and their relationship management and its influence on the outcome of technology development in the two Ethiopian S&T universities using agency theory. Based on the gaps identified in actor's relationship in the technology development management[6] process, the research aims to forward solutions from the agency and organizational control theory perspective. Hence, it will answer the following three research questions:

1. Who were the actors in the technology development process of Ethiopian S&T universities since 2015?
2. How did the actors' relationship influence the outcome of technology development in Ethiopian S&T universities since 2015?
3. What are the potential improvements needed in the actors' relationship to improve technology development outcomes in Ethiopian S&T universities?

1.4. Significance of the study

This study analysis is vital for three reasons:

- ✓ It can potentially contribute to empirical studies on university-based technology development for transfer in developing countries, especially from the Ethiopian institutions' perspective. Since the challenges of developing countries in the subject are unique, lessons can be taken based on the shared features of science and technology universities in other developing countries.
- ✓ It can potentially be a valuable resource for policy and decision-makers at MoSHE and the two S&T universities. This is vital since, the two universities and the technology transfer mission are part of Ethiopian national industrialization policy (FDRE, 2010; MoFED, 2010).
- ✓ An exploratory analysis will create agendas and context for future studies (Yin, 2011), and hence, this study will forward potential research agendas based on its findings.

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[5] In many literatures, the word "actor" refers to principals and agents (see Braun & Guston, 2003). This research also categorizes the actors as principals and agents in the analysis when relevant

[6] The word "governance" is used to represent the relationship between principals and agents in a contract (see Eisenhardt, 1989; Kivistö & Zalyevska, 2015). The term *management* is used in this paper since the study primarily focuses on institutional-level analysis.

1.5.Structure of the paper

This thesis is divided into six chapters. The first chapter provides the research background and articulates the study's rationale and the predicted outcomes. The second chapter of the literature review explains three topics of interest. The first section describes university-based technology development and transfer under the umbrella of the third mission of higher education institutions. The second section elaborates on the theoretical lenses used the agency theory and organizational control theory, which complement the former. Finally, the analytical framework is presented based on the theoretical lens in technology development and transfer from literature. The literature review chapter also aims to show a research gap in the study.

The third chapter is research methods, which argues the suitability of research design, describes the source of data and data analysis methods utilized. Chapter four is data analysis and results, which shows the thematic analysis and results of data and information acquired based on the components of the analytical framework developed. Chapter five discusses the findings and interprets the study results based on the theoretical lens employed. Finally, chapter six concludes by answering the three research questions raised based on the analysis results and discussion of the research. It also contains the research outcomes, the implications for practice and theory, and limitations and closes with future research agendas.

Chapter Two: A Review of Literature

2. Literature review

This chapter provides the background for the third mission of higher education institutions, in which university-based technology development and transfer is a significant part. Based on the assertion of Xiao and Watson (2019), this literature review identifies research "gaps" and problems (p.7). It also elaborates the relationship between concepts (i.e., third mission, technology transfer, and technology development in this case) and explains the research's intent as it is one purpose of a literature review (Rocco & Plakhotnik, 2009).

To this end, keywords such as "third mission," "technology transfer," "technology development," "agency and principal-agent theory," and "organizational control theory" were combined with "university" and "higher education institutions" were searched to find at least peer-reviewed journals, edited monographs, one Ph.D. thesis, and books on *Google scholar, Research Gate, Jstor, science direct, Springer Link* among others to develop the theoretical framework. After the third mission and technology transfer and development, the theoretical and conceptual framework is discussed.

2.1.The third mission of universities

Higher education institutions have been expanding their mandate beyond teaching and research to include the "third mission" (Predazzi, 2012; Marhl & Pausits, 2013). Governments usually facilitate universities' mission adoption through clear and "significant new funding opportunities" and schemes (Marhl & Pausits, 2013, p. 45). So far, there are no consistent and concise definitions for universities' third mission (Berghaeuser & Hoelscher, 2020; Predazzi, 2012). Meanwhile, some meanings and explanations reflect the diversity of the concept, changing implementation practice, and the focus of research interest.

According to Berghaeuser and Hoelscher (2020), since Etzkowitz and Leydesdorff used the term "third mission" for the first time in their article published in 2000, its significance has been connected with universities' contribution to local economic development. According to Secundo et al. (2016), the third mission should be wide enough to contain universities' interaction with their environment. Similarly, Berghaeuser and Hoelscher (2020) argue that its scope to expand beyond economic contribution to include social engagement. For Gaisch et al. (2019), the third mission elements encompass "Entrepreneurial University," "Triple Helix" and "Mode 2," and "Regional Innovation Systems," which reflect universities' economic roles, while "Engaged University" and "Sustainable University" represents non-economic aspects of the mission (p.2). Simply put, Nelles and Vorley (2010) define, in general terms, the third mission as a phenomenon representing the social and economic interaction of universities with their environment.

In comparison to universities' typical teaching and research missions, the third mission, often known as outreach or community service, is significant for the external stakeholders it serves and the "partnership" relationship status with the same (Jongbloed et al., 2008, p.313). According to Predazzi (2012), the third mission's objective is to establish dialogue and a clear connection between science and society. Many agree on the close connection and overlay between the two old missions of higher education institutions and the third mission (Gaisch et al., 2019; Jongbloed et al., 2008).

Why are universities embracing the third mission?

Adopting the third mission by universities is seen as a hallmark of following "modern" universities (Predazzi, 2012, p.518). Accountability for resources obtained from the state (Marhl & Pausits, 2013) and accountability to stakeholders (Ricci & Civitillo, 2017) are also reasons to incorporate the mission. Berghaeuser and Hoelscher (2020) discovered that universities use "ceremonially institutionalized structures, techniques, and policies" to respond to external pressure and demonstrate conformity in implementing the third mission. In several countries and regions, universities are evaluated based on their "engagement" significance level and accountability to society as a whole and stakeholders (Jongbloed et al., 2008, p.313). For example, in German universities, the third mission is alluded to as a mandate of universities, and academic staffs are expected to actively participate, along with specific bylaws to regulate the operation (Berghaeuser & Hoelscher, 2020).

In sum, the main reason for the third mission practice's popularity is that it is typically a national policy-driven pursuit (Marhl & Pausits,2013; Nelles & Vorley,2010), adopted by universities to gain legitimacy (Secundoet et al., 2016), backed by a legal framework at the national and institutional levels (Berghaeuser & Hoelscher,2020).

2.2. Third mission-related research agendas

There has been considerable research investigating the third mission's components and challenges in various institutional and country contexts (Koryakina et al., 2015). These include internal and external factors that contribute to the challenges and responsibility to stakeholders and the third mission components (Ricci & Civitillo, 2017). Universities in Italy, for example, consider the third mission synonymous with technology transfer (Della Volpe & Esposito, 2020). In Sweden, universities emphasized the third mission's commercialization activities and unheeded the social part of the third mission (Schnurbus & Edvardsson, 2020). A similar finding was reported on German universities for their focus on economic output and technology transfer overlooking the civic and continuing education contributions (Berghaeuser & Hoelscher, 2020). Other research areas of interest include third mission performance (Secundo et al., 2016), avenues for integrating third mission performance in global university ranking systems (Marhl & Pausits, 2013; Montesinos et al., 2008), comparative study of nations' third mission policies (Pinheiroa et al., 2017), and the role of universities' third mission in regional growth (Salomaa, 2019).

However, internal management, faculty, and mission-related systems have received less attention (Rubens et al., 2017), indicating a research gap. For this paper's purpose, it is critical to narrow down the broader third mission-related discussion to one of its components, technology transfer which is specifically relevant in this case.

Technology Transfer (TT) as a component of the third mission

According to Marhl and Pausits (2013), activities representing the third mission of universities are "continuing education," "technology transfer and innovation," and "Social Engagement" (p.45). Secundo et al. (2016) refer to these as third mission targets, and Berghaeuser and Hoelscher (2020) refer to them as mission categories. According to Predazzi (2012), technology transfer is the third mission's main component, and institutions put it in their organizational structure to support their third mission (Hellström et al., 2013). Taouaf et al. (2020), for example, suggested a comprehensive framework for establishing a technology transfer office in Moroccan universities after existing structural elements failed to produce the required results in the third mission engagement (p.2). Technology transfer is the universities' primary enabling mechanism for the third mission (Carboni & Orazi, 2016).

As such, the third mission focuses on academic spin-offs such as startups and the creation of innovative products and processes (Carboni & Orazi, 2016, p.24). Similarly, Hellström et al. (2013) note that technology transfer is a commercial operation of the third mission and that the mission's meaning can be narrowed down to it as it relates to "commercialization of research" (p.195).

2.3.Technology and technology transfer

The concept "technology" in university-based technology transfer context has been defined in multiple ways. Arenas and González (2018) reviewed 66 papers on technology transfer to define technology transfer components. One of their findings was the "object" of technology transfer, which represents what is transmitted to a recipient. The object representation of technology includes "scientific expertise," "prototype," "know-how," "process design," and "technology advancement"

(Arenas & González, 2018, p.10). Bozeman (2000) used the word "tool" in a comprehensive literature review on technology transfer, a commonly perceived representation of technology (p.628).

Hence, technology transfer can be defined by breaking down the two terms: technology and transfer. At the core of it, the fundamental building block of technology is "knowledge about the physical world and how to exploit it for human purposes" (Eveland, 1986, p.305). According to Sahal (1981; 1982), as cited in Bozeman (2000), knowledge transfer and technology transfer are inextricably linked. This is because the knowledge on which the technology is developed is transferred when technology is transferred. This is analogous to Rogers and Klepper's (1977) definition, according to which technology incorporates instruments, physical or procedural, and the tool's use or intent, as cited in Eveland (1987).

Hence, a transfer is the physical movement of an item from one party to another for use (Eveland, 1987). The new technology should be communicated to facilitate the receiver's use (Eveland, 1987). As a result, technology transfer is described as the "application of information" embedded in technology innovation (Gibson & Rogers, 1994 as cited in Rogers et al., 2001, p.254). The word "innovation" refers to a "new concept, practice, or thing" (Rogers, 1995 as cited in Rogers et al., 2001). Hence, technology transfer is the movement of scientific discoveries, technical advancement, and other innovations and technologies originating at universities for practical application to other recipients (Rogers et al., 2001).

There are processes in place to facilitate the transfer of technology, especially from universities. First, technology transfer can occur through "spin-offs" by creating a new company based on the new technology (Rogers et al., 2001, p.255). The second mode of transfer is "licensing," in which an innovator or individual with the proper grants consent or gives the right to "create, use, and sell" an innovation output such as a process, design, or product (Annon, 1995 as cited in Rogers et al., 2001, p.255).

Technology transfer offices (TTOs) act as "technology intermediaries" (Markman et al., 2005, p.242) or "central agents" (York & Ahn, 2012, p.27) in charge of turning state-funded technologies in universities into commercially viable products (Kireyeva et al.,2020). USA's Bayh-Dole Act[7] was a pioneer legislation in introducing technology transfer practice in universities (Mowery & Sampat, 2005). Many countries in Europe and beyond attempted to replicate the Bayh-Dole Act,

[7] Under the Bay-Dole Act of 1980, institutions of higher learning in the US were permitted to patent and license technology that they developed using government research funding (Mowery & Sampat, 2005).

which aided in establishing TTOs in universities, thus making technology transfer the primary component of the third mission (Xu et al., 2011; Nelles & Vorley, 2010; Mowery & Sampat, 2005). Technology transfer from university to the industry has become a crucial government strategy, as the third mission, in general, is (Abbas et al., 2018; Marhl & Pausits, 2013). As such, TTOs play an essential role in ensuring that universities contribute to economic growth through a third mission approach (Kireyeva et al., 2020, p.735)

2.3.1. Technology transfer research agendas

There are few empirical studies on the technology development process within universities with the end goal of transfer. Most university technology transfer literature reviewed focuses on quantitative research and formal aspects of technology transfer rather than organizational problems within universities (Rolfo & Finardi, 2014). Generally, research works focus on the best models of technology transfer (Kundu et al., 2015), the efficacy of external communication and commercialization (Bozeman, 2000), the form of technology, expense, and timing of technology transfer (Stock & Tatikonda, 2000; Meseri & Maital, 2001; Heslop et al., 2001). These indicate that university technology development and transfer internal management challenges are less studied like the third mission of universities.

Based on national and institutional heterogeneities, a query in technology transfer is context dependent (Wahab et al., 2009). For example, in Norway, because the institution was in the early phases of its technology transfer engagement, a lack of proper commercialization triggered an evaluation on the TTO by focusing on "organizational and developmental" factors rather than "productive and outcome" features (Gulbrandsen,2010, p.26). This empirical study implies that an institutional level analysis works well when TTO operations are in their early stages and with low performance, justifying the approach taken in this case study.

Furthermore, concentrating on technology development projects is critical as it is one factor for effectiveness in technology transfer and commercialization efforts. According to Heslop et al. (2001), evaluating the characteristics of technology development projects that ultimately achieve commercial success is a less well-researched subject. As a result, they developed a technology “readiness assessment” tool (Heslop et al. 2001, p.373). This includes stages such as project selection, power of the support system, and the technology itself, as well as a “functioning prototype” (p.373). These stages indicate the internal technology development process from selection to its output. Additionally, while their instrument is based on advanced technology transfer systems in the United States and Canada, they asserted that their work’s focus on technology development projects benefits any scenario involving technology development and transfer.

2.3.2. TTO's internal operation features

The TTO's internal operation and performance in the technology development process can be seen from multiple perspectives. Secundo et al. (2016) defined six performance areas that TTOs can monitor, three of which are internal to the TTO and the technology itself, using a "maturity model" to calculate the efficiency of technology transfer. Among the metrics used are

- "*TTO employees' abilities*"
- "*TTO's support role structure*"
- "*The level of technology advancement and the merit of the discloser*" (p 49).

According to Gulbrandsen (2010), TTO staff composition represents academic and business expertise based on their technology transfer program. In a study conducted in German universities by Hülsbeck et al. (2013), "division of labor" and "specialization of tasks" were found to be very important for the success of technology transfer, mainly because "adverse selection" has an impact on acquiring the required skills for TTO's performance (p.211).

On another study, Friedman and Silberman (2003) discovered that "faculty quality" is critical for producing commercially appealing innovations (p.19). Similarly, Jensen et al. (2003) found out that disclosing technology to TTO is contingent on academic staff quality in US universities. As such, academic staffs with high-potential innovations are less likely to report them quickly, and those who have revealed their innovation quickly have questionable quality. The proximity of the TTO to technology-accepting industries and the size of the TTO (i.e., funds and human resources) have all been found to be crucial to the TTO's success (Bozeman,2000). On the other hand, Kireyeva et al. (2020) claimed the problem in TTOs of Kazakhstan universities and other post-soviet countries is "university bureaucracy" and "lack of economic incentive," among others (p.738). These results suggest that TTOs in universities face internal management problems and the need to analyze actors' relationships with related factors affecting their operation.

Internal actors' relationship was highlighted as research interest in literature. In an extensive analysis of universities in Ireland, New Zealand, and the United States, O'Kane et al. (2015) clarified the competing needs of actors within universities that the TTO office should manage. These researchers labeled TTOs as commercialization agents in their relationship with university scientists and administration. This is because the scientists and management are unaware of property rights and commercialization, in which TTO is specialized to process (O'Kane et al., 2015, p.423). TTO's primary aim, as Siegel et al. (2003) noted, is to "secure and market the university's intellectual property" (p.31). Meanwhile, scientists are more concerned with technology advancement than commercialization, while management is more concerned with sales and strategic issues (Siegel et al., 2003, p.31).

In conclusion, studying internal actors and their relationships (O'Kane et al., 2015) and technology development projects of technology transfer (Secundo et al., 2016) are relevant, particularly when actual technology transfer fails to materialize (Gulbrandsen, 2010). Accordingly, this case study employed agency and organizational control theories as a complementary theoretical lens to examine the internal relationships among actors in the technology development process and its influence on the outcome.

2.4.Theoretical framework: Agency theory

This section aims to review the theories employed in this research, agency theory coupled with organizational control theory, as a lens through which the research was analyzed. The theoretical framework describes the specific theories and associated concepts to be used in the research (Rocco & Plakhotnik, 2009). As such, the Agency theory originated in economics and was later applied in an organizational setting (Shapiro, 2005; Eisenhardt, 1989), making it relevant for this study.

Agency theory defines a typical relationship in which one person, known as a principal, entrusts another person, an agent, to carry out a job (Eisenhardt, 1989). As a result, an agency agreement is established when one party is named as an agent for, represents, or is employed or empowered by the other, a principal, for a specific decision need (McGuire, 1988; Ross, 1973). Hence, it is a dependency relationship in which one person, the principal, is influenced by and "depends" on the actions of another person, the agent (Pratt & Zeckhauser, 1986, p.2).

The dependency relationship is related to the principal's innate inability to carry out the task and the agent's capacity to do so at a "lower cost" (Fleisher, 1991, p.120) due to the agent's advanced expertise, as in the case of professionals (Shapiro, 2005). In an agency relationship, the principal relinquishes the "power" over his or her activities and decisions in a specific and bounded area while gaining the right of control over agent's activities and decisions (Braun, 1993, p.137). On the other hand, the agent relinquishes the power to control one's conduct in a specific and limited area in exchange for the authority to act and make decisions on behalf of the principal (Braun, 1993, p.137). Meanwhile, in an agency relationship, the "loss of resources" is a significant element to conisder (Braun, 1993). The principal is the party who "disposes" of resources to the agent so that the agent can use them to pursue the principal's interest (Braun & Guston, 2003, p.303), and the agent is rewarded for fulfilling that interest (Fleisher, 1991). Relationships between employer and employee, state and governed (Ross, 1973), buyer and seller (Eisenhardt, 1989), doctor and patient, and consultant and client (Pratt & Zeckhauser, 1986) are all examples of agency relationships.

The principal-agent relationship is detected by a contract, written or otherwise (Mahaney & Lederer, 2003) or through a hierarchical decision and control relationship, or a combination of the two (Kivistö & Zalyevska, 2016; Fama & Jensen, 1983). For example, Van Slyke (2007) asserted that in the public sector, the arrangement between the agent and the principal includes "inputs, procedures, results, rewards and penalties, and quality performance-reporting requirements" (p.162). Rasmussen and Gulbrandsen (2010) suggested that an agent's responsibilities are typically defined in strategic and budget documents in addition to contracts.

2.4.1. How does the theory work?

The theory works when the agent and principal participate in "cooperative action" while having "differing goals and attitudes toward risk" (Eisenhardt, 1989, p.59). The agent usually is "closer" to the job or understands it better than the principal in an agency partnership (Pratt & Zeckhauser, 1986). Meanwhile, the principal could know what should be "accomplished" as an outcome (Pratt & Zeckhauser, 1986, p.3).

Meanwhile, the theory is driven by the assumptions it holds about individual behaviors such as "self-interest" and "risk aversion," as well as "goal conflict" among people in organizational settings (Eisenhardt, 1989, p.58). In most cases, the principal may not maintain complete and cost-free information about the agent's actions (McGuire, 1988; Pratt & Zeckhauser, 1986). Thus, the agency theory suggests that each party acts in their self-interest, including "optimizing" their rewards and acting per their various risk preferences (McGuire, 1988, p.6).

Therefore, agency theory aims to address two issues that can occur in an agency relationship. The first is when the principal's and agent's interests or objectives are at odds, and it is difficult or expensive for the principal to determine if the agent is complying (Eisenhardt, 1989). The problem in this situation is that the principal may be unable to "verify" whether the agent behaves properly (Eisenhardt, 1989, p.58). The second scenario is a "risk-sharing" scenario between the agent and the principal because they have "different risk attitudes" (Eisenhardt, 1989, p.58). The issue here is that divergence in risk perceptions may lead to divergence during action or performance in the agency relationship (Bergen et al., 1992; Eisenhardt, 1989). The theory's goal in resolving the two problems is to arrive at an "efficient contract governing" the relationship (Eisenhardt, 1989, p.58).

Meanwhile, the theory prescribes a contract with the best possible result for the principal under the constraints of the partnership, rather than mutual benefit maximization (Bergen et al., 1992). As a result, in agency theory, the principal determines how the agent performs and acts in the principal's best interests (McGuire, 1988) by aligning the evaluation and incentive mechanism with the principal's expectations and action preferences (Shapiro, 2005; Fleisher, 1991).

However, the principal's gain, which is the outcome of the task, is influenced by other external factors (McGuire, 1988; Bergenet al, 1992) beyond the control of the principal and agent (Petersen, 1993). As a result, simply tracking an agent's actions or outcomes may not accurately portray the agent's performance (McGuire, 1988). Such external factors include "other agency relationships," regulators, and "legal rules" (Shapiro, 2005, p.269) and many more in economics and marketing-related agency relationships, creating uncertainty about the outcome (McGuire, 1988; Bergen et al., 1992). As a result, the objective of agency theory can be deduced from variables indicating the behaviors of the parties involved as explained by goal conflict, environmental conditions, and uncertainties, and inaccessible or costly information about an agent's conduct and its consequences (1988; Bergen et al., 1992; McGuire, 1988). It is also vital to know the assumptions behind an agency relationship. The following sections explore more details about agency theory (i.e., branches and types), assumptions, variables, and description of agency problems.

2.4.2. Branches of agency theory

Agency theory has evolved through time. The agency theory originated from two streams: the "positive theory of agency" and the "principal-agent theory" (Jensen, 1983, p.334).

The positive theory of agency principle is that the contract between an agent and principal with opposing objectives and desires is the source of the agency problem in agency relationships (Eisenhardt, 1989; Jensen, 1983). The solution it proposes is based on the "qualitative" and "institutional facts" that characterize the "contracting relationships" (Jensen, 1983, p.332). This hypothesis assumes that the "selected action" would result in the desired outcome (Jensen, 1983, p.322). As a result, Eisenhardt (1989) asserts a governance mechanism that limits agents' "self-serving behavior" (Eisenhardt, 1989, p.59) and opportunism through an outcome-based contract to address the problem (p.60). The logic is that outcome-based contracts bind both parties' interests because the ultimate reward for both is dependent on the same result of the task, an outcome (Eisenhardt, 1989, p.60). The other option is that the principal should gather detailed information about its agent's "actual doing," as a result; the agent understands that adverse activity can be observed and refrains from it, mitigating opportunism (Eisenhardt, 1989, p.60).

On the other hand, the principal-agent theory proposes the most efficient contract under various conditions of uncertainty, risk-driven preferences, and information structure (Eisenhardt, 1989; Jensen, 1983). Both branches of theories are “complementary” in that they address contracting issues that could emerge from self-interested parties in an agency partnership (Jensen, 1983). Consequently, the principal-agent stream focuses on crafting the optimal contract, behavior versus outcome, using quantitative methods under various theory assumptions and variables (Eisenhardt, 1989, P.60). The primary method of principal-agent theory research is to use agency variables such as task programmability, information asymmetry, and outcome uncertainty to decide whether the contract should be behavior-based or outcome-based (Shapiro, 2005; Eisenhardt, 1989).

2.4.3. Agency relationship types and levels

This segment addresses two debatable agency partnership scenarios. The number of agents and principals involved in an agency partnership is the first (Shapiro, 2005; Waterman & Meier, 1998). The presumption that agency relationships have unitary actors is questioned, and the possibility of multiple actors and levels of relationship is acknowledged (Shapiro, 2005; Waterman & Meier, 1998). For example, in a bureaucratic process, the availability of multiple principals, two principals hiring one agency, or multiple agents and a principal is normal scenario (Shapiro, 2005; Waterman & Meier, 1998). Meanwhile, these types of situations complicate the agency relationship. For example, if two principals share the same agent and have competing priorities and desires, and the contracts are intentionally ambiguous (Shapiro, 2005), the relationship would be “exceedingly complex” (Waterman & Meier, 1998, p.179). A principal with multiple agents would almost certainly face information asymmetry and monitoring difficulties (Mason et al., 2006; Shapiro, 2005). This is due to the possibility of diverse agent interests and differences in risk and incentive preferences among agents (Shapiro, 2005). On the other hand, competing agents may help the principal get the necessary information if competition exists among the former (Waterman & Meier, 1998).

The second long-held assertion that agency theory only considers individual level principal and agent relationships (Pratt & Zeckhauser, 1986) is also called intra-organizational relationships (Kivistö, 2007a). The process of applying the theory outside of the economics discipline has put this conclusion into question (Shapiro, 2005). The principal-agent relationship can occur at the group or organizational level (Kivistö & Zalyevska, 2016), referring to an inter-organizational relationship (Kivistö, 2007a). Mason et al. (2006) conducted a sports-related analysis in which they labeled International Olympic Committee (IOC) members collectively as principal and individual members as agents in the committee’s task of selecting cities to host the Olympics. According to Kivistö

(2007a), organizations are taken for granted as principals and agents without a specific description. From the “methodological individualism” of organizational economics viewpoint, organizations should not have a real personality distinct from individual members (p.13). This is because methodological individualism states that any social and economic event is explained by individuals’ “conscious action” (Donaldson, 1990, p.371).

Accordingly, Kivistö (2007a) argues that organizations can be agents and principals so long as their actions are explained through their members' actions (p.14). Furthermore, if an organization's "boundaries and purposes" are established, as individual principals' and agents' would be, considering organizations as agents or principals is a viable proposition (Kivistö,2007a, p.15). Finally, he contends that in inter-organizational agency relationships, there is no need to abandon the intra-organizational agency relationship assumptions of "differences in interest, goal, and action" (Kivistö, 2007a, p.15). This is realistic since only a portion of an individual's ideas practically materialize at the individual or organizational level, even though individuals have several competing ideas in their minds before deciding which action to take (Kivistö, 2007a).

2.4.4. Agency theory assumptions

A theory should encompass "variables constructs and concepts" to elaborate phenomenon of interest, and factors that add little value to its application should be omitted (Whetten, 1989, p.490). A good theory should explain "why" or the "rationale" to support the theory (p.493). As such, the agency theory has assumptions that illustrate principals' and agents' behaviors and explain agency problems that arise in the relationships. Meanwhile, it is critical to understand that behavioral assumptions regarding agents, principals, and their relationships vary depending on the field of application and the "paradigm" context (Kivistö, 2007a, p.16). This concept is relevant since institutions and units are taken as actors and categorized as principal and agents. The assumptions of an agency relationship are explained by self-interested parties, risk preference, goal conflict, and information asymmetry.

Self-interested parties

An agency theory addresses a contracting dilemma involving self-interested parties (Jensen, 1983). A self-interested agent chooses “specifications” that provide the highest return for his/her own goals, regardless of the principal’s interest (Mitnick, 1975, p.29). When an agency partnership is founded on economic and marketing partnerships, self-interest may move from maximizing benefit or utility to opportunism (Bergen et al. 1992; Jensen, 1983).

Opportunism is characterized as a cunning pursuit of self-interest in an agency relationship (Arrow 1971 as cited in Wright et al., 2001). In an agency partnership, agents with opportunist behavior change or forward limited information (Williamson,1975 as cited in Kivistö,2007a) to conceal, deceive, distort, or steal (Wright et al., 2001). For example, if an agent fails to achieve the desired result, he or she may blame the uncertainty factors for the failure (Petersen, 1993). Even if rewards and control mechanisms are available, opportunism can prevail due to "adverse selection" or "moral hazard" (Wright et al., 2001, p.415), as discussed later.

Risk preference

Outcome uncertainties and risk-taking disparity determine the contract between a principal and an agent (Eisenhardt, 1989). A principal is usually risk-neutral while the agent is risk-averse (Shapiro, 2005; Bergen, et al., 1992). One reason an agent withholds information that is harmful to the principal's interests is to shield himself or herself from risk (Shapiro, 2005).

Goal conflict

Goal conflict refers to a conflicting interest between the principal and the agent or partially overlapping priorities (Rasmussen & Gulbrandsen, 2012). This may result in an agent's failure to try to fulfill a principal's interests, creating a moral hazard known as shirking (Eisenhardt, 1989). Goal dispute is addressed further in the agency variables discussion since it is also considered a variable (Waterman & Meier, 1998).

Information asymmetry

Information asymmetry arises when the principal has trouble tracking the agent's capacity, level of expertise, hidden motive, and behavior (Saam, 2007). Petersen (1993) goes into detail regarding the information asymmetry assumption. Accordingly, both the principal and the agent may monitor the task's outcome, but the agent may observe his or her conduct, while the principal may do so at a cost. Arrow's (1985) classification of the "hidden action" and "hidden knowledge" model is alluded to by Petersen (1993, p.279) to explain the assumption further.

In the hidden action model, the principal can only see the outcome of the task, whereas the agent can observe his or her actions, capabilities, and unpredictable variables before deciding on a course of action (Petersen, 1993). The principal can track the agent's behavior and capacity in the hidden knowledge model, but not the agent's action's uncertainty factors. This deprives the principal of understanding if the agent chose the appropriate action following the principal's interests (p.279).

Finally, goal conflict and information asymmetry assumptions are thought to be constant in all agency relationships as assumptions, but Waterman and Meier (1998) argue that they should be treated as variables.

2.4.5. Agency problems

The roots of an agency relationship problems are the principal's and agent's differing goals and risk preferences (Bergen et al. 1992; Eisenhardt, 1989), combined with the principal's lack of complete information about the agent's capability and behavior (Eisenhardt, 1989). Consequently, two possible problems arise, an adverse selection and moral hazard (Eisenhardt, 1989). The agency problems are adverse selection and moral hazard.

Adverse selection

This agency problem emerges from the beginning of the principal-agent relationship (Bergen et al., 1992). Adverse selection can occur before entering a contract while selecting the agent with the appropriate abilities and characteristics (Bergen et al., 1992, p.2). The agent may claim to process unique skills and abilities, but the principal may not thoroughly verify those skills and abilities during the recruiting and even while the task is in the process (Shapiro, 2005; Eisenhardt, 1989). This is known as the adverse selection dilemma (Braun & Guston, 2003), which might lead to an "unwise" selection of an agent (Ferris & Graddy,1998, p.228). Mitigating this issue is critical since an agent's commitment alone would not suffice to achieve the principal's goals without having the requisite skills and abilities, making a difference by choosing the suitable agents (Fleisher, 1991).

Moral hazard

Moral hazard occurs when the agent fails to exert effort per the relationship's agreement (Shapiro, 2005; Eisenhardt, 1989) after the agent has begun executing the assignment (Ferris & Graddy, 1998; Bergen et al., 1992), which may result in shirking (Eisenhardt, 1989, p.61). Kivistö (2005) gives a distinct feature for shirking. He explains shirking as a "deliberate" action of working contrary to the specifications set in the agreement of an agency relationship (p.4). It breaches the terms of the agreement while having an informational advantage over the principal (Braun & Guston, 2003; Ferris & Graddy, 1998), the agent pursues own private interest (Kivistö, 2005). Once an agent is chosen, one way for mitigating moral hazard is to link the agent's reward to the result of the action or to track the action while the task is in progress (Petersen, 1993). In the meantime, Braun and Guston (2003) argue that there is little discussion on the possibility of the principal shirking in literature, but it is possible in the circumstances such as withholding promised incentives and failing to supply the necessary resources.

Normative solutions for agency problems

There are two ways for the principal to pursue minimizing agency problems, adverse selection, and moral hazard, arising from "unobservable conduct" (Eisenhardt, 1989, p.61). The first approach is to obtain an information system, and the second is to make the contract outcome based (Eisenhardt, 1989; Eisenhardt, 1985). The information system involves gathering information to pick the best agent and effectively track and execute the contract (Ferris & Graddy, 1998). According to Eisenhardt (1989) and Shapiro (2005), the principal may obtain information and control using a budget allocation method, establishing a board, building a reporting procedure, appointing auditors or managers, and additional institutional structure. The aim is to shift the information asymmetry to complete information for the principal, but this comes at a cost (Ferris & Graddy, 1998; Eisenhardt, 1989). For instance, the costs of moving information up the hierarchy in a tiered public institution structure are associated with implementation and communication costs (Ferris & Graddy, 1998).

Making the contract an outcome-based contract as another alternative is determined by factors such as the principal's and agents' uncertainty and risk expectations (Eisenhardt, 1989; Ferris & Graddy, 1998). Furthermore, it should be combined with an appropriate incentive scheme to "motivate" the agent to meet the principal's target (Bergen et al., 1992, p.4). As a result, the efficacy of this choice is dependent on other variables, which will be addressed in the section on agency theory variables as follows.

2.4.6. Variables in agency theory

The agency theory's principal-agent stream is dedicated to determining whether a contract should be behavior-based or outcome-based based on various agency variables, particularly task programmability, information system, and outcome uncertainty (Eisenhardt, 1989). According to Kivistö and Zalyevska (2016), agency theory variables indicate the gaps in an effective contract under different circumstances. They also discovered four essential variables that are widely used to determine the most effective contract: "outcome measurability," "outcome uncertainty," "task programmability" and goal conflict" (p.138). The following section addresses the agency theory variables, and outcome uncertainty is discussed under the outcome measurability variable since the uncertainty is about the outcome. Moreover, the outcome measurability variable is discussed with an outcome-based contract and task programmability with a behavior-based contract. This is because the two variables determine the type of feasible contract to apply (Eisenhardt, 1989).

Goal conflict

The source of goal conflict in an agency relationship is self-interest, which is the agency theory's core assumption (Kivistö & Zalyevska, 2016). Waterman and Meier (1998) argue goal conflict should be treated as a variable in an agency relationship, as it may or may not occur in a "bureaucratic environment," as opposed to, for example, an agency relationship in a market system, where it exists by default (Waterman & Meier, 1998, p.185). They gave an example of how a political leader and an executive branch of government may or may not agree on policy to illustrate the goal conflict in a public institution setting. However, in marketing, the seller (i.e., the agent) attempts to get as much revenue as possible, and the principal (i.e., the customer) attempts to pay as little as possible, and hence, the goal difference is apparent (p.185).

Moreover, based on situational factors such as "need for achievement" (McClelland, 1960, as cited in Wright et al., 2001, p.418), the agent may go over and above the given specifications, necessitating the relaxation of goal conflict as a variable than as part of the theory's assumptions (Wright et al.,2001). The best solution for goal conflict between the principal and an agent is to close the gap in their goals, which may be eroded over time, making it a non-viable option (Kivistö & Zalyevska, 2016). The other option is using an outcome-based contract, which is appropriate when there is a goal conflict since it provides agents with the motivation to fulfill the principal's interest when it is strongly bounded with reciprocal incentives (Kivistö & Zalyevska, 2016; Mahaney & Lederer, 2003).

Outcome measurability and outcome-based contracts

The principal can underwrite an outcome-driven contract in which the agent is evaluated based on the materialized final output or performance outcome (Bergen et al., 1992). The conditions for using this contract model mainly depend on measuring and tracking the outcome (Ferris & Graddy, 1998). Outcome-based contracts are ideal if the principal can reliably observe, measure (Mahaney & Lederer, 2003; Kivistö, 2005b), and assess the agent's operation outcome at a low cost (Ferris & Graddy, 1998; Petersen, 1993). Moreover, an outcome-based contract is the best choice when the agent's actions are difficult to track while performing, and the success is only expressed in the outcome (Bolz, 2017). However, defining outcome and its measurement and finding the suitable entity to set measurements are controversial in agency theory and easier said than done (Kivistö, 2005).

The difficulty in enforcing this contract stems from the complexity of translating an agent's actions into an outcome (Ferris & Graddy, 1998, p.228). The agent's behavior's outcome might be determined by external factors called *outcome uncertainty* factors outside both parties' control (Petersen, 1993; Bergen et al., 1992; McGuire, 1988). In other words, the agent can obtain a poor result despite his or her efforts, and vice versa (Eisenhardt, 1989). When outcome uncertainty factors make the agent's effort less-impactful on quality and quantity, using an outcome-based contract is unfair (Kivistö, 2005).

Thus, if the task's outcome is unpredictable, agents will avoid outcome-based contracts because they would bear the risk of failure and naturally want to avoid it (Ferris & Graddy,1998). Consequently, the principal may fail to find "interested" agents in such scenarios (p.228). This contractual arrangement is beneficial for a risk-averse principal, especially when the outcome is uncertain (Lasser and Kerr, 1996; Eisenhardt, 1989).

However, since outcome-based contracts shift risk from the principal to the agent, the reward should also motivate the agent (Bergen et al., 1992) and make an agent "work harder" (Kivistö, 2007a, p.28). Setting an incentive or sanction clause for completing or failing to complete the assignment on time is an appropriate payment scheme for this contract type (Shapiro, 2005).

Similarly, where there is a high degree of goal conflict between the principal and the agent, and an outcome-based contract is better for the principal to achieve the desired outcome (Lasser & Kerr, 1996; Eisenhardt, 1989). Outcome-based contracts are useful for aligning the two parties' goals (Van Slyke, 2007; Bergen et al., 1992) and compelling the agent to act in the principal's best interests (Eisenhardt, 1989). As a result, it is critical to understand the agent's "personal ambitions" and the compatibility of the principal's and the agent's goals (Bergen et al. 1992, p.5).

Task Programmability and behavior-based contracts

A behavior-based contract is seen as an alternative contract that depends on task programmability. A principal may create a contract that determines how the agent will be evaluated and rewarded based on the actions the agent demonstrates (Bergen et al., 1992). A behavior-based contract depends on the availability of information and the possibility to observe behavior (Eisenhardt, 1989). The availability of reliable information is needed to enable behavior-based contracts (Eisenhardt, 1989) by improving monitoring capability and task observation (Lasser & Kerr, 1996; Eisenhardt, 1989). It necessitates a detailed control procedure rather than relying on the parties' tacit understanding and trust (Schillemans & Bjurstrm, 2020; Fleisher, 1991). However, access to such information does not come without cost.

As a result, the principal incurs "specification cost" on the resource and time needed to monitor the agent's behavior and action to minimize the possibility of shirking by the agent (Fleisher, 1991, p.121). Meanwhile, a behavior-based contract shields the agent from outcome uncertainty (Kivistö, 2007a). If the agent's task is too sophisticated, making task programmability impossible for the principal's direct control, or if it is too expensive, and an outcome-based contract is feasible for the principal (Kivistö & Zalyevska, 2016).

As a result, the best option is to keep the cost of acquiring information as low as possible while also ensuring a reasonable level of performance from the agent (Shapiro, 2005; Fleisher, 1991, McGuire, 1988). The behavior-based contract incentive scheme includes a reward for choosing to perform a job and an incentive for the time spent on the task, such as a fixed salary (Shapiro, 2005; Petersen, 1993).

Outcome-based contract and behavior-based contract trade-offs

According to Lasser and Kerr (1996), the choice of contract type, outcome, or behavior-based, is determined by the comparative cost advantage of monitoring behavior and the reward scheme paid off for the principal's desired outcomes (p.615). Similarly, Eisenhardt (1989) posits that the option between outcome and a behavior-based contract is a "trade-off" between the cost of behavior control and the cost of outcome evaluation (61). In terms of application, a contract can include a combination of outcome and behavior-based contract (Petersen, 1993), or in a "continuum" between them (Eisenhardt ,1989, p.71).

However, if measuring outcome and task programmability are complex and impossible (Eisenhardt, 1989), the agency theory does not explicitly forward the means to manage the agency relationship. In the context of this research, innovation-related activities such as technology development, the scenario is possible to happen. For example, Ouchi (1979) contends that it is difficult to establish "rules and behaviors" that a scientist should exhibit and to measure the output of their research or scientific work because it takes years to produce outcomes (p.844). As a result, organizational control theory, to handle such scenario, is used to supplement agency theory in this study to bridge this gap.

2.5.Organizational control theory

One of the suggestions made in Eisenhardt's (1989) classic work on agency theory is to use other theories to enrich the application of agency theory. As such, it is vital in this study to combine agency theory with organizational control theory. The aim of combining a theory is to provide "a range of insights" or "explanations" (Cairney, 2013, p.3), in this case study, by complementing agency theory with organizational control theory[8]. In control theory, what is measured as individual's performance is either the "behavior of an employee" or the "outcome of those behaviors" (Thomspon, 1967 and Ouchi ,1979 as cited in Eisenhardt, 1985, p. 135). The former calls for behavior-based control and the latter outcome-based control.

Outcome-based control is accomplished by setting “targets” and desired “ends” of a performance (Snell, 1992, p. 296). Behavior-based control involves defining and programming tasks leading to an outcome (Eisenhardt, 1985 p. 135). Task programmability is defined as the “task's susceptibility to clear specification of behaviors required to execute it” (Govindarajan & Fisher, 1990, p.261). Meanwhile, output measurability is defined as the “output's susceptibility to reliable and valid measurement” (p.261).

The general proposition in both agency and organizational control theory is that if task programmability is feasible, behavior-based control is feasible to exercise, which refers to behavior-based contracts (Eisenhardt, 1985). If the goal can be vividly stated inside an organization and its outcome can be calculated, the outcome control technique is sufficient, managed under an outcome-based contract in an agency relationship (p.136). Meanwhile, both agency and control theories assert outcome-based contract and control are a means to create a common goal (Van Slyke, 2007; Bergen et al., 1992; Eisenhardt, 1985).

2.5.1. Complementing Agency theory by Organizational control theory

The organizational control theory's contribution in this study is its proposition of control approaches when neither task programmability nor outcome measurability is possible at the same time for a given task. In such a scenario, “minimizing divergence of preferences (i.e., the people side of control)” (Eisenhardt, 1985, p.136), also known as clan socialization, is a viable option as a control strategy (Snell, 1992). Hence, a socialization approach is essential, and building shared goals and value-based commitment is the best control strategy when neither behavior nor outcome-based control is possible (Eisenhardt, 1985).

Organizational control theory also suggests input control, which refers to employees' knowledge and skill as an input (Johnson, 2011), like agency theory's selection of the right capable agent to prevent adverse selection (Eisenhardt, 1985). The control theory takes the selection process as one

[8] Control theory is used to refer to organizational control theory in this paper for simplicity

control strategy for a better outcome. Moreover, inputs include physical materials and facility needed for technology development (Johnson, 2011).

The rationale for merging the two theories in this study relates to the particular feature of the study subjects', university academic staff. Abernethy and Stoelwinder's (1995) argument on agency theory and Ouchi's (1979) organizational control theory explain such unique features in studying these subjects. High-level professionals who work in the public bureaucracy have a role conflict of maintaining their professional interest with needs in bureaucracy (Abernethy & Stoelwinder, 1995). Professionals also do not like it when the principal imposes outcome-based control over them (Abernethy & Stoelwinder, 1995) and anything that limits their self-control (Shapiro, 2005; Abernethy & Stoelwinder, 1995). Similarly, Ouchi (1979) asserts that it is difficult to set "rules" for research or scientific work and prescribe the "behaviors" that each test should exhibit and measure their work's output since it takes time to see the result of such work (p.844). The control theory suggests "socialization" and "training" to change past systems and thinking and create shared value (Abernethy & Stoelwinder, 1995, p.13). Hence, it is vital to incorporate control theory when task programmability and outcome measurability is impossible.

Whereas agency theory explicitly emphasizes the importance of an information system, uncertainty, cost, and incentives, control theory glosses over these aspects by not addressing them specifically (Eisenhardt, 1985). On the other hand, control theory emphasizes task programmability and outcome measurability and includes "people" or social control as an alternative to the two control methods (Eisenhardt, 1985, p.139). Hence, agency theory is broader in the variables and assumptions it holds, and control theory is called in a situation where outcome measurability and task programmability are challenging, a complementing juncture in this research (see table 1).

Table 1 Agency and organizational control theory nexus

Variable Scenario	**Agency theory approach to contract**	**Organizational Control Theory (OCT) approach to control**
If either task programmability and outcome measurability or both are possible	Other variables affect contract type choices, such as cost and risk perception and outcome uncertainty	Either outcome or behavior-based control or both are possible (i.e., indifferent about the choice)
If neither task programmability nor outcome measurability is possible	-	*Use people side of control or clan socialization and input control

Note: * A complimentary nexus between agency theory and control theory for this research

2.6.Analytical framework: Agency theory in the context

This section explains the operationalization of the theoretical framework in technology development in the technology transfer context for analysis. Hence, it identifies the variables to be used and the assumptions to be taken and elaborate on the relationship among variables.

2.6.1. Assumptions and variables to employ

Identifying the assumptions and variables of agency theory is critical to utilize the right approach of analysis. The behavioral assumptions regarding principals and agents (Kivistö, 2007a) and the variables (Waterman & Meier, 1998) to use for analysis depends on the context of application. Since the origin of the agency theory is in economics, when used as a lens in different settings such as organizational context, some assumptions and variables diminish in their importance. Some of the assumptions and variables in this research are excluded from the study while using agency theory.

Self-interest: This assumption is also labeled as “human assumptions” and may not necessarily be directly employed in an organizational setting (Eisenhardt, 1989, p.580). The self-interest assumption leads agents to pursue their own goals in an agency relationship (Eisenhardt, 1989; Mitnick, 1975). Similarly, Kivistö and Zalyevska (2016), by citing Jensen’s work of 1994, elaborated assumptions such as self-interest should be viewed considering the goal conflict it causes between an agent and a principal in cooperative engagement. Heath (2009) argues it does not matter if the agent is "egoistic," and what agency theory should consider in a practical sense is that each party looks after their goal irrespective of having a "selfish" personality or otherwise. Moreover, Heath (2009) further argues that the goals of one party are manifested in an agency relationship so long as it affects the other party's goal. Hence, self-interest leads to goal conflict (Kivistö & Zalyevska, 2016), and directly addressing the goal conflict is the objective of this paper than testing the underlying assumptions of self-interest.

Risk aversion is also a type of human-related assumption in an agency theory (Eisenhardt, 1989). The outcome-based contract generally transfers risk to the agent, and the behavior-based contract transfers risk to the principal (Bergen et al., 1992). However, Kivistö (2007a) argues the risk aversion assumption works best in "market-like situations" where there is a scarcity of agents or principals, and there is a "freedom" to join and leave the agency relationship (p.24). He further argues that higher public higher education institutions, by and large, do not have such relationship features. Hence, the risk aversion personality of agents and principals will not be tested in this study. In general, the human-related assumptions of self-interest and risk preference (Eisenhardt, 1989) are not a part of this study's analytical framework. This research will use goal conflict and information asymmetry, classified as "organizational assumptions" by Eisenhardt (1989, p.59), which is also treated as a variable.

Cost: Cost plays an important a role in choosing between an outcome-based and behavior-based contract between a principal and an agent (Lasser& Kerr,1996). However, agency costs are complex, which includes costs that are incurred because of divergence in interest, the cost to choose the best agent, costs for gathering information to prepare standardized performance metrics, monitoring costs, and "loss" due to the agent's incompetent decision (Panda and Leepsa, 2017, p.84). Kivistö (2008) states that computing the "cost of governance" is nearly impracticable in higher education institutions, but it can be indirectly explained in the plan and personnel required to monitor. Costs like "opportunism cost" incurred, visible or otherwise, are even more challenging to measure, and still, those costs can be analyzed and recognized using proxies (Vining & Globerman, 1999 as cited in Kivistö (2008).

Moreover, Waterman & Meier, (1998) strongly argue that in public institutions, a principal in charge of regulation is unlikely to personally incur cost to decide that it is in his or her "rational self-interest" not to monitor an agent, which amounts to shirking in public institutions (p.175). Hence, monitoring could not be abandoned with cost justification in public institutions, which is a relevant argument in this study since the two universities are public institutions.

Finally, Kivistö (2005) argues that researchers should use deeper analysis of variables to decide the contract type using outcome measurability, task programmability, outcome uncertainty, and goal conflict variables rather than relying on cost primarily. Hence, cost analysis in the decision-making of contract type is beyond the scope of this paper.

2.7. Analytical framework and operationalization

This section aims to explain how the agency theory is applied in empirical technology development studies for the technology transfer purpose. As such, it categorizes, explains, and illustrates (Rocco & Plakhotnik, 2009) the relationships between technology development and the agency theory for the study's analysis.

The analytical framework drives its components from applying the theory from literature in the context of higher education institutions (see Kivistö & Zalyevska, 2016), projects since technology developments are projects (see Gulbrandsen & Rasmussen, 2012) and public sector (Waterman & Meier, 1998). The subject of the study shares these features since the technology development projects are in public universities.

2.7.1. Principal(s) and agent(s) in technology development

Identifying principals and agents and their goals is one of the foundations of using agency theory in research (Gomez-Mejia et al., 2005). Empirical studies used hierarchical, financing, and oversight relationships to define principal-agent relationships in technology development and transfer activities (see O'Kane et al., 2015; Rasmussen & Gulbrandsen, 2012; Fama & Jensen, 1983).

The relationship between a government and a higher education institution is the first potential principal-agent relationship in the higher education system. Any public higher education institution founded by a legal statute is subject to government “oversight” (Lane & Kivistö, 2008, p.141). As a result, the government is a principal, and the university is an agent (Lane, 2007). As the government entrusts universities with tasks and allocates money for the same, it develops an interest in monitoring the tasks in the institutions (Kivistö & Zalyevska 2016, p.134).

Devolved fiscal arrangements or performance-based budgeting in the public sector can be viewed as contractual relationships with the potential for agency problems (Ferris & Graddy, 1998). The governance mechanisms that connect universities to their financial source, the government, vary from one country to another (Lane & Kivistö, 2008). As previously mentioned, from the perspective of agency theory, the principal's resource is a necessary pretext for the agency relationship (Rasmussen & Gulbrandsen, 2012; Braun, 1993). This goes along with the broader government-funded and driven third mission in universities. Since governments are typically the primary drivers of third mission and technology through funding, an accountability relationship is usually established (Marhl & Pausits, 2013), an agency relationship in this case.

Similar agency relationships are established when any government or ministry of education uses an intermediary funding agency for research institutions. For example, Gulbrandsen and Rasmussen (2012) conducted a study in Norway on FORNY[9], a research funding agency that collects funding from different ministries and channels it to universities, TTOs, and commercialization ventures. Gulbrandsen and Rasmussen (2012) designated FRONY as an agent to the ministries and a principal for organizations it provides funding (i.e., TTOs and fund recipient projects). TTO, in turn, was labeled as an agent of FRONY. Similarly, Braun and Guston (2003) studied a relationship between science policymaking, an intermediary research funding council, and scientists receiving funding. They classified the relationship between policymakers and the council on one side and the council and scientists on the other as a principal-agent respectively. When the agency relationship is formed between states and an intermediary funding agency, established by the former, and the university, the relationship is inter-organizational, as mentioned in Kivistö (2007a).

Meanwhile, this research focuses on technology development through TTOs, and there have been empirical research findings that have dedicated agency relationships within TTO systems in higher education institutions. O'Kane et al. (2015) and Jensen et al. (2003), in an empirical study, characterized TTO as an agent working to meet the needs of two principals, academic staff and university administration. Meanwhile, Gulbrandsen (2010) and Gulbrandsen and Rasmussen (2012) identified TTO as a principal to academic staff and an agent to university management.

The identification of principals and agents depends on the context of the relationship, among others. For example, O'Kane et al. (2015) used TTO as an agent because the TTO's position in their case study was to commercialize on behalf of the scientists and the university. Meanwhile, Gulbrandsen's (2010) case involved an autonomous TTO that solicits projects and academic personnel for technology development and commercialization on behalf of the university, with a structured contractual arrangement in the agency relationship (Gulbrandsen, 2010). Within universities, the agency relationship may take the form of individual relationships, such as those between a scientist working on technology creation and TTO officials (see Jensen et al., 2003). Such relationships can be categorized as intra-organizational relationships, as described by Kivistö (2007a).

[9] Norwegian government research funding and support agency

Operationalizing the principal-agent relationship

The first step in applying agency theory was defining agency relationships (i.e., principals and agents). To describe and categorize actors with agency relationships in depth, hierarchical and legal relationships (Kivistö & Zalyevska, 2016), contractual agreements (Auld, 2010; Gulbrandsen (2010), and reporting relationships were scrutinized (see figure1).

2.7.2. Goal and goal conflict in a technology development context

Goal and goal conflict is another component of agency theory to be considered in this study. States can compel higher education institutions, primarily public institutions, to report their objectives to the public or enter into direct contractual agreements with them (Auld, 2010). In general, there is a possible goal conflict between the government and academia: the former prioritizes "influence" and "revenue," while the latter prioritizes "quality" and "efficiency" (Kivistö & Zalyevska 2016, p.136).

In an empirical study, Gulbrandsen and Rasmussen (2012) also address the possible goal disparity, related to technology transfer mission, between the intermediary funding agency and scientists, noting that the former generally prefer "spin-offs" and "commercialization," while the latter seek autonomy and more funding (p.530) and pursue own research interests (Gulbrandsen & Rasmussen,2012; Wright et al., 2004). Johnson (2011) mentioned the same goal difference between university administrations involved in commercialization and academic personnel interested in following "esoteric" research (p.844). This is related to what O'Kane (2018) stated, technically, that scientists' roles are focused on the input, research, side of technology transfer, while technology transfer offices (TTOs) participate in the output side, commercialization. Siegel et al. (2001) argued that scientists' primary motivation for participating in technology transfer is "recognition within the scientific community" via publishing and presentation at prestigious conferences, with financial and other support as a secondary objective (p.31).

Moreover, if TTO serves two principals, inherently, it will be exposed to the contradictory interest of management's pursuit for more commercialization and the academic staff's interest in science and autonomy (O'Kane et al., 2015). Gulbrandsen (2010) described "conflicting," "overlapping," and "unclear" objectives set by a university, the principal, were found to be an agency problem in the empirical study (p.32). For example, the university set the target of becoming the best "entrepreneurial" university, but little consideration was given in its strategic plans. Similarly, another example of goal conflict is when one party sets broader goals, such as giving "social benefit," in contrast to a limited goal set by the other party, such as increasing revenue from commercialization (Gulbrandsen & Rasmussen, 2012, p.530). Goal conflict should be minimized since TTOs and universities with straightforward and concentrated goals outperform institutions with numerous goals (Friedman & Silberman, 2003).

Finally, in this research, in light of empirical research findings showing goal conflict in technology development and transfer in each case (see Gulbrandsen and Rasmussen, 2012; Johnson, 2011; O'Kane et al., 2015; Gulbrandsen, 2010), it is treated as a variable (see table 1). In line with this, Kivistö (2005) argues that for an agency relationship to work, goal conflict should not necessarily be perpetual, but there should be "certain potential" for it to happen (p.1).

Operationalizing the goal conflict

Many studies have found a gap in the priorities of the TTO office, technology developers, university administration, and funding institutions in universities' technology development and transfer. This distinction is due to the mission of each actor, such as technology developers interested in gaining scientific exercise and autonomy, TTOs, and university management and funding agencies with the goal of commercialization and revenue (Gulbrandsen & Rasmussen,2012; Wright et al., 2004). To identify goal and goal conflict, relevant institutional documents, and stated goals and missions (Friedman & Silberman, 2003) from the principals and agents identified were analyzed and substantiated by interviewing participants, to incorporate goals in practice.

2.7.3. Asymmetry of information

This is the assumption from agency theory that was used to analyze the process of technology development in this study. At the national level, the working relationship between research institutions and their overseeing ministries may be a source of information asymmetry because of the working relationship distance between the two (Caswill, 1998). Hence, using intermediary agencies such as “research councils” with professional and institutional closeness with academic agents minimizes information asymmetry and “handles” moral hazard (p.294).

However, the most significant information asymmetry is that researchers are aware of the research they perform while those who regulate, as principal, are not (Guston, 1996). Moreover, the sophisticated innovations in higher education institutions inherently produce information asymmetry (Kivistö & Zalyevska, 2016). Similarly, TTOs may not have complete knowledge of technology developers and their technology’s commercialization potential while it is being developed (Gulbrandsen, 2010). Hence, technology developers have the most knowledge of the science, while TTO has a greater understanding of commercializing technology (Johnson, 2011). The information asymmetry is typically in “favor” of the technology developer in the early stages of the project, and as the project advances to the prototype level, the TTO may have better information about the output (Johnson, 2011, p.846). This is especially significant given the importance of academic staff's quality for the success of technology development and transfer (Secundo et al., 2016; Friedman & Silberman, 2003).

Operationalizing asymmetry of information

The information asymmetry scenario is identified mainly in the gap of know-how about technologies developed between technology developers and other actors involved as principal and agent (Guston, 1996). Moreover, potential scenarios of information asymmetry during selecting technology development projects and during carrying out the development (Johnson, 2011) among principals and agents were scrutinized. One of the manifestations of information asymmetry seen includes over-reporting the agent's success during project development, as Mahaney and Lederer (2003) specified.

2.7.4. Agency problem

The relationship between agents and principals has consequences, including agency problems. The agency problem of adverse selection and moral hazard is caused by information asymmetry and goal conflict (Bergen et al., 1992; Eisenhardt, 1989). The agency problems were discovered in empirical studies of the technology development process in TTOs (Gulbrandsen & Rasmussen, 2012; Gulbrandsen, 2010).

Adverse selection

This agency problem arises throughout the national level process of selecting relevant institutions, intermediaries, funding organizations, and higher education institutions for technology transfer (Rasmussen & Gulbrandsen, 2012; Guston, 1996). For instance, when higher education institutions are required to compete for resources, they may alter their actual capacity and preparedness to meet the goals set, resulting in adverse selection (Kivistö, 2005).

The selection of technology projects and scientists participating in TTO is vital to its success (Johnson, 2011). It is not easy to provide complete project details at an early stage of technology development to enable informed selection of projects (Agrawal, 2006 as cited in Gulbrandsen & Rasmussen, 2012). Hence, the person in charge of overseeing the projects is dependent on the technology developer's behavior and value commitment to the project's efficiency (Rasmussen & Gulbrandsen, 2012).

One strategy for selecting the correct technology is to use peer review and/or technical experts to minimize adverse selection (Rasmussen & Gulbrandsen, 2012), which Gulbrandsen (2010) refers to as a bottom-up approach. TTOs with many project disclosures from academic staff pick technology at an advanced or prototype level to reduce the risk of a weak technology project pick (Jensen et al., 2003). As such, many factors influence practical means of managing adverse selection. In universities that rewarded TTOs based on the number of technology disclosures from the academic staff, the latter made a poor choice of technology by funding initiatives with poor commercialization prospects (Gulbrandsen, 2010).

Operationalizing adverse selection

Adverse selection problems in selecting technology developers and technologies (Agrawal, 2006 as cited in Gulbrandsen and Rasmussen, 2012) are analyzed along with the approaches used to mitigate them and their gaps. The adverse selection scenarios were investigated at project selection and execution stages. However, when adverse selection is difficult to detect at the beginning, moral hazard during performance can be traced back to adverse selection (Kivistö, 2005). Since this study is a retrospective study and adverse selection problems are extracted from problems during the project development, among others (see figure1).

Moral Hazard

At the higher education institution level, there may be a moral hazard if formal agreements are violated (i.e., shirking), or goals are deviated from, such as diverting funding to the institutions' priorities rather than the government's (Kivistö, 2005). In an empirical study, Rasmussen and Gulbrandsen (2012) identified a potential moral hazard in which universities failed to finance their TTOs despite having the financial capacity to do so to maintain the state funding.

Additional empirical studies on technology development and transfer using agency theory at the institution level have also detected additional moral hazard issues. Gulbrandsen (2010) identified a moral hazard from the TTO side, in which the university demanded the university's "right to all patentable innovations," and the TTO was mandated to execute it. The TTO, on the other hand, was hesitant to undertake the responsibility to maintain a smooth "relationship" with academic staff (p.35). This gave academic staff the option of patenting their invention through their organizations, creating moral hazard (i.e., for the agent to behave unacceptably). Rasmussen and Gulbrandsen (2012) asserted that TTOs in their case study might have created a moral hazard by rerouting funds to non-priority areas and establishing enterprises with insufficient commercial viability to secure the incentive given on new firm formation.

Technology developers also commit moral hazard, for instance, due to the TTO's compensation scheme to the developers as identified in a large-scale study by Jensen and Thursby (2001). Most licensed technologies in their case study were discovered to be early, and "further development" was needed for commercialization (Jensen & Thursby, 2001, p.255). The researchers' inference was that to ensure the developer's return to work on licensed technologies, the royalty or equity value should be linked to the licensee's output (Jensen & Thursby, 2001p.255).

Operationalizing Moral hazard

Indicators of moral hazard in higher education institutions include low productivity and gaps in the efficacy of mobilizing resources (Kivistö, 2005). In empirical studies in technology development, moral hazard has been identified from various actors' interest from professional (i.e., technology developers) and institutional responsibility (TTO and university management) perspective (Gulbrandsen, 2010), among others. The moral hazard problems emanating from goal conflict and information asymmetry are identified using the analytical framework (see figure 1).

2.7.5. Type of contract and variables

The type of contract selected between the principal and the agent should respond to the goal conflict and information asymmetry context in an agency relationship (Eisenhardt, 1989). Moreover, the agency variables should be considered while picking the ideal contract type (Kivistö and Zalyevska, 2016).

Kivistö (2005) asserts that agency variables, mainly; outcome measurability, task programmability, outcome uncertainty, and goal conflict, are the core components of agency theory. The outcome-based contract mainly depends on the measurable outcome, and the behavior-based contract calls for task programmability (Eisenhardt, 1989).

Measurability of outcomes and outcome-based contract

Based on the agency relationship, the contract type can be seen at the university level, TTOs', and technology developers' level. Economic outcomes of technology development initiatives, such as licenses and spin-offs, are desirable outcomes from the standpoints of national ministries, university administrations, and TTOs (Gulbrandsen & Rasmussen, 2012). The numbers of patents, startups, industry-funded research, profits from industry, among other metrics, are used to assess the performance of university TTOs (Ustundag et al., 2011).

According to an empirical study, a Norwegian intermediary finance agency looks at the total number of commercialization licenses and startup firms when evaluating and making future funding decisions (Rasmussen & Gulbrandsen, 2012). However, there is no performance assessment on "product development" (p.534), even though it is the valid measure of outcome according to scientists (Siegel et al., 2003). Meanwhile, Bozeman et al. (2015) identified universities evaluating TTOs based on adherence to the agreed-upon completion of projects and transfer specifications. Evaluation of project completion can be done within the boundary of TTOs compared to other evaluation performance measures (Bozeman, 2000).

Meanwhile, TTOs may impose outcome-based control on technology developers using a variety of performance criteria. Output-based metrics are used in technology development to evaluate "the technology itself, prototype development, licensing, royalty, patent, and publication" (Johnson, 2011, p.850), which is analogous to an outcome-based contract in an agency theory (Eisenhardt, 1985).

However, *outcome uncertainty* is high, especially at the project level for technology development and transfer projects, which affects the project's outcome (Rasmussen and Gulbrandsen, 2012). Tasks in higher education institutions are generally unique and non-repetitive (Kivistö, 2008), rendering outcome-based contracts challenging to apply. Considerations of uncertainty are more critical in technology development than in any other type of product development, needing increased uncertainty management to meet project objectives (Rasmussen and Gulbrandsen, 2012; Eldred & McGrath, 1997). Moreover, setting project time for technology development is challenging, and that "too much structure" stifles innovation, signaling the uniqueness of technology development projects (Eldred & McGrath, 1997, p.44).

Principals use funding and incentive systems to enforce an outcome-based contract. At a national level, governance based on university outcomes is typically enforced by "output-based funding," which includes allocation based on the number of patents (Kivistö & Zalyevska, 2016, p.137). Payments to scientists, such as royalties, are benefits correlated with the outcomes of licensing agreements for technology development and transfer (Friedman & Silberman, 2003).

Operationalizing outcome-based contracts, outcome measurability, and outcome uncertainty

Indictors of technology development and transfer projects' outcomes are usually related to the commercialization of technology outputs (Johnson, 2011). The outcomes are measured by different actors using proxies such as patent and license (Rogers et al., 2001), prototype development, and startups (Johnson, 2011), among others. Hence, the measurement approach on the outcome of technology development is also analyzed in this study, and if it is the right approach.

The external and uncertainty variables that influence the outcome of a task in an agency relationship usually pertain to complex agency relationships involving "other agency relationships," regulatory and other legal boundaries (Shapiro, 2005, p.269). Hence, such variables are scrutinized. Hence the outcome-based contract in technology transfer is analyzed from the outcome uncertainty and measurability perspective (see figure 1).

Task Programmability and Behavior-based contract

A behavior-based contract has its feature as an alternative to an outcome-based contract. The contract between the government and universities is more likely to be behavior-based enforced through monitoring, field visits, evaluation, appraisals, and audits (Kivistö & Zalyevska, 2016). Universities usually work under procedural constraints, including "rules and guidelines" and laws and regulations in a government-university relationship (Schillemans & Bjurstrm, 2019, p.9). Specific monitoring tools include "reporting processes," "budgeting systems," different "layers of management" (Kivistö, 2005, p.6), and "line-item budgeting" (Kivistö, 2005 as cited in Kivistö & Zalye, 2015). This may result in the "accountability paradox," in which accountability for procedures takes precedence over accountability for results (Kivistö, 2005, p.9).

TTOs, as principals, may use "rules and procedures" for lab facility use, predetermined steps for projects to make task programmability possible (Johnson, 2011, p.850). These are examples of behavior-based contract tools in an agency theory (Eisenhardt, 1985). York and Ahn (2012) take the same approach, claiming that setting precise targets at each point of progress enhances task programmability. Rocha and Romero (2012) also claim that technology assessment for technology development and transfer involves a "pre-defined checklist" depending on the progress level of the technology and evaluation during the entire process of a project (p.706). Furthermore, a hierarchical system manages and executes the contracts between principals and agents (Hill & Jones, 1992).

Operationalizing outcome-based task programmability and behavior-based contract

The behavior-based contract will be identified based on the funding system applied in the agency relationships (Kivistö, 2005 as cited in Kivistö & Zalye, 2015) reporting procedure, governance structures (Schillemans & Bjurstrm, 2020; Johnson,2011) to control the activities of the task are all indicators of behavior-based contract.

Yet, task programmability, which is highly affected by information asymmetry, determines the possibility of using behavior-based contracts (Kivistö, 2005). Task programmability is possible if a straightforward way of specifying the behavior needed to complete the given task (Johnson, 2011, Kivistö, 2005) can be achieved.

Task programmability and outcome measurability hurdle

When task programmability and outcome measurability are not feasible in a particular agency relationship, organizational control theory fills the gap in managing the relationship (Johnson, 2011). Because of unique features, universities, outcome measurability, and task programmability are challenging to achieve in higher education institutions (Kivistö, 2008; Kivistö 2005; Mahaney & Lederer, 2003).

According to Ouchi (1979), in a researchers' case, the best way to mitigate the challenge is to hire the right professionals (i.e., input control), observe them through conferences and workshops, and develop mutual values and objectives through joint activities. Workshops and seminars in control theory are defined as clan socialization necessary for the university and researchers to establish common goals (Ouchi, 1979). Furthermore, professionals are interested in "self-control" (Abernethy & Stoelwinder, 1995, p.3). For example, in research and publication setting peer review method, which is one form of supervision by the principal on top of self-control, can be used (Shapiro2005).

Note on the analytical framework

The analytical framework explains how the phenomenon of the study, the technology development in Ethiopian S&T universities, will be analyzed and discussed. To operationalize the framework, it is vital to show how the variables are related using arrows and boxes (Whetten, 1989). The following steps explain the analytical framework adopted for this study (see figure 1). The first step is to identify the principal-agent relationship and how the relationship is formed (i.e., legal, funding, hierarchical, written contract, etc.). Then the goal conflict and information asymmetry in the relationship are identified along with the resulting agency problems. Side by side, the technology development outcome measurability, task programmability, and outcome uncertainties and their relationship with goal conflict and information asymmetry in the process were scrutinized and the current contract type practice is identified.

The analysis is also devoted to seeing whether there is a mismatch between the current contract type, goal conflict, information asymmetry, agency problems and outcome measurability, task programmability, and outcome uncertainty that the agency relationship is experiencing. Finally, solutions were proposed to gaps identified to address the third research question. Hence the objective of the research is not only to analyze the agency relationships among actors and subsequent agency problems but also to identify gaps and forward solutions for the same.

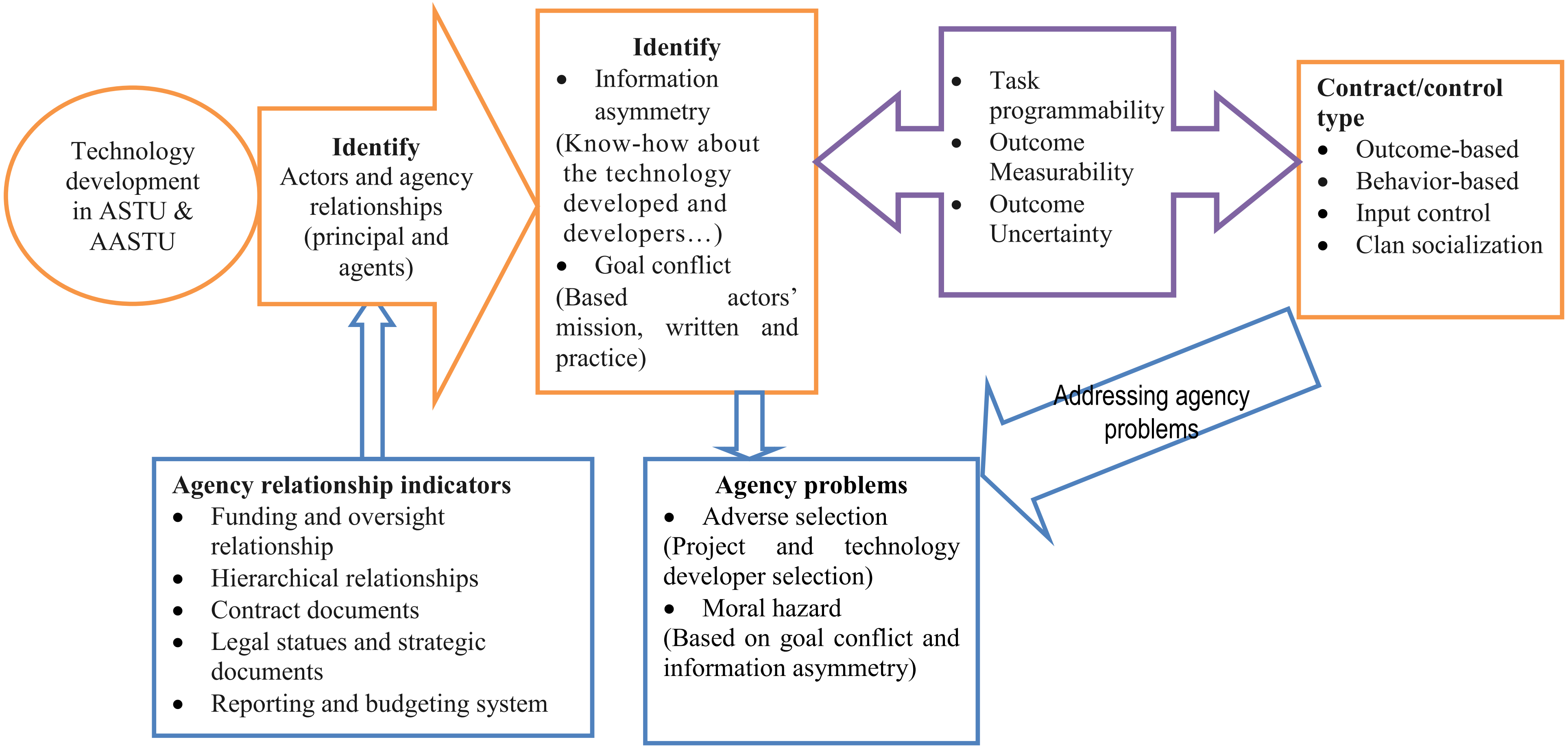

Figure 1.Analytical framework

Note: The figure is compiled based on the literature review and analytical framework and operationalization section

Chapter Three: Research Methods

3. Research design

A qualitative study design was used to get a thorough understanding of a particular context (Yin, 2011; Creswell, 2007), in this case, technology development in Ethiopian S&T universities. As such, the research was conducted in universities, which are "natural settings" (Creswell, 2007, p.39), where technology developments happened, and data was collected directly by the researcher and gathered from the participants' perspective (Yin, 2011; Creswell, 2007).

The use of a qualitative research technique was justified by past research findings and the merit of qualitative research in this context. As such, the topic necessitates "detailed" and "complex" contextual comprehension calling for this approach (Creswell, 2007, p.40). According to Göransson et al. (2009), technology transfer projects in developing countries must be contextualized, requiring extensive exploration, for which qualitative research is ideal. This study used a case study technique since the study investigated a more extensive context using many sources of information, and it is a context-based inquiry (Yin, 2011; Yin, 2003).

The case study strategy employed in this research is a "multiple case study" model centered on a particular task, method, or program (Creswell, 2007, p.74), which is a technology development project. In order to produce contextual diversity two institutions and multiple technology development projects were included, which is appropriate for exploratory study (Yin, 2003).

As the theoretical lens through which this work is examined, agency theory is paired with organizational control theory. The agency and organizational control theories are suitable in case study research and are specifically used by Johnson (2011) for university-based technology development. Similarly, Tornatzky (2001) used agency theory to assess effective strategies in technology transfer in a comparable retrospective case study.

The goal is to analyze the practice of technology development in Ethiopian S & T universities for the first time, which makes it exploratory research (Creswell, 2009). Furthermore, the participants in the technology development process at the two S & T Universities were small in number, which can be addressed through interviews and document analysis, making qualitative research the best design choice (Creswell, 2007).

3.1.Sampling method and Participants

Census was used to select technology developers for interview, and purposive sampling was employed to select officials, as a qualitative analysis methodology since there is a need to obtain accurate information on the key issue (Creswell, 2007): technology development projects. "Units" that provide the most relevant and abundant data for the issue under study (Yin, 2011, p.88) were selected. Because the study focuses on technology development practice over five years, participants in the project or activity were the best source of "retrospective information" (Yin,2011, p. 88). The sampling was planned based on the location, procedure, and level of engagement (Creswell, 2007, p.126).

The study locations were the two S & T universities in Ethiopia because they have been designated with a specialized mission of technology development and transfer (Baumann & Lauberbach, 2019). The TTOs of the two universities oversee technology development projects within the universities, process wise. Academic staff members who participated in technology transfer programs were taken at the participation level. The entire list of projects was taken (see table 2) based on the information from TTOs, and because their number was discovered to be small, all participants were considered for an interview, or a census approach was used (Creswell, 2012) but few developers could not be reached for interview.

The projects selected were technology transfer projects initiated by the academic staff and technologies with a physical prototype output (Arenas & González 2018, Johnson, 2011), tools or technology devices (Bozeman, 2000), and with software and information technology outputs. The technology development initiatives came from Mechanical, Automotive, Electrical, and Computer Science and IT programs of the universities (see appendix 3).

Hence technology development in this study refers to projects

- ✔ Undertaken under the mandate of the technology transfer office of the two universities
- ✔ Initiated by academic staffs
- ✔ With a prototype, technology device or a tool, software, or IT outputs

According to officials interviewed, except for one project at AASTU, all Technology Development projects were launched in teams, as a norm. This is primarily to ensure project continuity if the initiator could not work on the project for some reason, such as study leave.

Nonetheless, team member selection is the responsibility of the project's principal developer, who is usually the project idea initiator, or the person chosen to lead the project. As officials and participants from both universities asserted, the principal is responsible for overseeing the project and its finances and outcomes. As a result, the principals of the project were interviewed, as a participant, for this study. According to project developers interviewed for this study, team members were typically chosen based on “technical competence” and “friendship,” according to project developers interviewed for this study. Meanwhile, depending on the diversity of expertise required to complete the project, the team could be made up of staff from various departments.

Additionally, from a procedure perspective, officials involved in technology development and transfer process at TTOs, universities' top management position holders directly overseeing TTOs were interviewed through purposive sampling. In ASTU a former TTO official was included since there was a change in leadership in the TTO in the study period covered in this research. One official involved in the coordination of the two universities transition from the then Ministry of Education to MoST and with direct know-how on decisions made during the change was interviewed (see appendix 3). This contributed by offering historical background in structural changes in the face of lack of *institutional memory* from documents. The administrative officials were chosen through purposive for their experience and position to provide a detailed account (Etikan, 2016) of the institutions' financial and procurement systems with national and institutional context. The interview was done using a semi-structured interview instrument that was created specifically for this research.

Seven of the technology developers could not be found (see table 2) due to leaving the universities (i.e., four in AASTU and one from ASTU) and inconvenience to find them when they chose face to face interviews (i.e., two in ASTU). A total of 23 people were interviewed, and technology developers are labeled as participants and represented by the initial of participant “P.” TTO officials, a coordinator, and university top officials are all named as officials in this paper and represented by “F”[10], to maintain the anonymity of officials since some positions were held by a single person. The procurement and finance officials are represented by “A”[11] for anonymity (see appendix 3 for details and codes given).

[10] By taking the second letter in the word official
[11] Both directorates are under the administrative wing of the universities

The project developers, TTO officials, university top officials were the primary sources of information in this study. The interviews were conducted with a coordinator of universities' transition, procurement, and finance directorate officials to corroborate the formal structures identified and their relationships with national-level institutions with implications for the two universities' technology development process.

Table 2 Number of interviewees conducted

Project status and interview	**ASTU**	**AASTU**	**Total**	**Codes[12] given to participants**
Total projects since 2015	12	9	20	
Project developers interviewed	9	5	14	$P_{1,2\ldots}$
TTO official interviewed[13]	2	1	3	$F_{1,2\ldots}$
University level officials interviewed	1	1	2	
Coordinator in universities' transition in 2014/15	2	1	3	
Administration procurement and finance officials	1		1	$A_{1,2\ldots}$
Total interviewee			23	

Note: This table summarizes participants in an interview in this study

3.2.Methods of data collection and protocols

The information was gathered through document reviews and interviews, utilizing a custom-made interview protocol appropriate for case studies (Denzin & Lincoln, 2018; Creswell, 2007). The procedure, as a case study, began with identifying the case with distinct "boundaries" (Creswell, 2007, p.74). As a result, technology development projects run by academic staff at the two Ethiopian S & T universities' TTOs were selected. Interviewees were chosen from those who participated in the technology development process.

A thorough document analysis was conducted to define the participants and their relationships in the technology development process. The major documents examined were proclamations,

[12] The codes are used to represent participants in the analysis and result chapter

[13] There was a change in leadership in ASTU's TTO over the five years covered by the study; thus, one former official was interviewed, whereas there was no change in leadership at AASTU's TTO.

strategic documents and manuals, and external and internal technology development-related reports. The documents were obtained from universities and on the internet.

The document analysis was mainly used to map the technology development process and identify the actors and their relationship at the two S & T universities. The objectives and priorities of the institutions in technology development and transfer projects were also explored. A semi-structured interview methodology (Yin, 2011) was devised to examine the actors and their relationships in the technology development process at the two universities. Except for one, which was conducted over the phone, the remaining thirteen project developers were interviewed directly, one-on-one interview (Creswell, 2007). Interviews with technology developers and TTO officials were audio-recorded, and on average ranged in length from 25 minutes for projects in progress to 45 minutes for completed projects. The information gathered from interviews with the coordinator, finance, and procurement officials, and one top official in AASTU was written down during the interview.

The data source was triangulated mostly through document analysis and interviews to confirm the research's validity or accuracy (Creswell, 2009). Since, different actors (Creswell, 2009) were interviewed on the technology development and transfer program at the two S & T universities. Above all since this research was focusing on "practice" deviations from written documents in practice were identified and the practiced phenomenon was used in analysis and discussion and this is mentioned.

3.3. Methods of Data Analysis

As is typical in qualitative research substantial data was gathered (Creswell, 2007). After completing the data gathering from the document analysis and interview, the data was coded into chunks based on the thematic themes stated in the analytical framework as recommended by Creswell, (2009). Thematic data analysis was applied to understand the data based on the theoretical framework and thematic concerns found during the document review and interview (Creswell, 2007, P.75). Thematic analysis aids in focusing on a specific "central issue" that cannot be generalized beyond the case at hand but aids in understanding its confluence (Creswell, 2007, p.75). Since two sites were chosen as a case, "with-in case analysis" was applied to describe the difference between the two institutions in practice when it exists

(Creswell, 2007, p.75). Meanwhile, “Cross-case analysis” dominates the Analysis, clarifying the issues in both institutions and providing an interpretation of the meaning (Creswell, 2007, p.75). Finally, interpretation is provided based on “gaining knowledge of the issue” as the first time or exploratory research (Creswell, 2007, p.75).

Participants' claims were supported by experience, and the study included a variety of “perspectives” on a single subject (Creswell, 2007), which is crucial for triangulating data sources from many sources (p.47), including documents and technology developers and officials. Thematic data analysis was used, and code repetition, as well as context interpretation, is provided. This is because thematic analysis avoids the shortcomings of content analysis, which depends exclusively on the frequency, or the number of times “codes” are repeated by participants to interpret data (Joffe & Yardley, 2004). The codes were produced based on the research question and theoretical framework and the issue raised during the interview as suggested by Joffe and Yardley (2004, p.59).

First, the actors and interactions involved in technology development and the formal management process, and its components were mapped largely into the Technology development process. This includes a complete description of the “setting” (Creswell, 2007, 163). Following that, the material acquired through interviews was “classified,” and “themes” and “patterns” were established (Creswell, 2007, p.156). The Atlasti.ti software tool, available at Tampere University, was used to analyze the qualitative data gathered.

The data analysis followed both “categorical aggregation” and “direct interpretation,” as described by Creswell (2007, p.163). In the former approach, shared experiences were categorized and interpreted. In the latter approach, peculiar experiences were interpreted even if it was not shared. This is because the experience of each technology developer was unique and significant in its implication as key issue (Braun & Clarke, 2006). Hence, diversity of experience implies a diversity of practice and the multifaceted and dynamic scenarios encountered by actors in technology development at the two S&T universities. This is relevant in innovative projects such as technology development characterized by the uniqueness of each project (Eldred & McGrath, 1997). The Analysis and interpretations were given based on the theoretical framework (Braun & Clarke, 2006) since the themes developed were based on the research question and the analytical framework. In the analysis presentation, respondents are represented by the codes designated to them (see table 2). Finally, the research analysis was interpreted so that the study's participants use it to initiate change, a process known as a naturalistic generalization (Creswell, 2007, p.163).

3.4.Reliability and validity of data

Based on Creswell's (2009) interpretation, the following outlines were employed during the data analysis to verify the analyses' reliability and validity. For reliability, the interviews were audio-recorded, and the transcript was transcribed and double-checked for accuracy. The coding matches the research methodology as well as the analytical framework's agency theory aspects.

The source of data was triangulated through document review and interviews with technology developers and officials to guarantee the research's validity or accuracy (Yin, 2011; Creswell, 2009). Furthermore, in the two S & T universities, different actors were interviewed regarding the same subject of the technology development mechanism.

3.5.Ethical concerns

Creswell (2007) distinguishes three areas of ethical concern during research: data collection, analysis and interpretation, and research dissemination (pp.91-92). In Ethiopia, it is typical to receive a letter of support from the university where the researcher studies, stating the purpose of the study. As a result, the MARIHE program provided a formal letter, and both S &T universities received a copy of the letter. To protect the subjects, all essential information about the research's objective (Creswell, 2007) was explicitly communicated to the participants on the record as prescribed by Yin (2011). The confidentiality of the information obtained from participants is maintained by assigning letters and numbers to interviewees (see table 1). Hence, the data was analyzed as a whole to avoid identifying names and used letters to represent them, and participants were made aware of this ahead of time. The findings are generalizable to the two Ethiopian S & T universities and their governing bodies. Additional scenarios of contexts whereby the findings can be generalized for are discussed in the conclusion chapter of this paper.

Chapter Four: Data Analysis and Results

4. Content of data analysis and result

This section presents the analysis and result of the data collected from interviews and document review. The analysis follows a case study approach based on Creswell's (2007) summary of the content of a case study by citing the work of Stake (1995). Accordingly, the analysis starts by elaborating the context and background to explain the time and the site of the study or "vignette" (Creswell, 2007, p.195). A detailed technology development context analysis follows this. As described by Braun and Clarke (2006), individual, group, and commonly shared experiences are presented in the analysis if they are significant. This approach is relevant since technology development projects are unique and innovative, diversity of experience is the feature in each project (Eldred & McGrath, 1997).

4.1.Governance: National level Structural changes and actors

Structural changes

ASTU was an upgraded institution that changed its name from Adama University to ASTU in 2011 (Eckl et al., 2017), and AASTU was founded the same year as a new S&T university with the goal of "mirroring" ASTU (P.97). In 2014/15, the two institutions conducted a significant reorganization to reaffirm the mission associated with their names for the previous six years. In 2014/15, the Council of Ministers enacted an amended regulation that changed the accountability of the two S&T universities from the Ministry of Education to the Ministry of Science and Technology (MoST) (see for example FDRE, 2014), which was the first structural and legal change. In 2018, a new ministry, the Ministry of Science and Higher Education (MoSHE) was established to govern all institutions of higher education (MoSHE, n.d), including the two S&T universities (Fana, 2020).

An official who participated actively in the transition in 2014/15 (F4) reported that MoST and the universities began making "internal structure, budget, and academic program changes." Accordingly, units such as an Entrepreneurship Development Institute, Centers of Excellence[14], STEM center and University Industrial Linkage Directorates and Technology Transfer Office (TTO) were added to the Universities' organizational hierarchy under Vice President (VP) for

[14] These Centers of Excellence were established based on universities' primary areas of research (F6)

Research and Technology Transfer. Each newly formed unit, including the Technology Transfer offices (TTOs) of the two S & T Universities, developed new "guidelines" (i.e., OTTCS,2017 of ASTU and VPRTT, 2013[15] of AASTU) outlining the objectives and procedures of technology development and received approval from the top university management (F1, F6).

A financial commitment from the government has accompanied the structural changes in the universities. At the same time, the institutions developed *a strategic document* and a *budget plan* to be implemented with the coordination of MoST to secure budget allocation from the Councils of Ministers (F4). The budget allocation for both universities was equivalent, and it was prepared based on the strategic plan of the universities to carry out their new mission (F4). For example, ASTU's annual budget for community service and technology transfer tripled from a little more than seven million *birr*[16] to more than twenty-eight million *birr* in 2015/16 from the previous year budget (see appendix 1).

4.1.1. National level actors and universities

MoST/MoSHE and the universities: The legal accountability relationship of the universities to the ministry (i.e., MoST/MoSHE[17]) is manifested by a "reporting" relationship according to officials (F2, F6). Universities provide the ministry with a quarterly report called "activity report," referring to the *operation* or activity report of the university in a balance scorecard[18] reporting format (F1, F5).

The reporting process is initiated, first, with universities developing an annual plan subdivided into quarterly plans for each program (i.e., teaching, administration, research, and technology transfer)[19] in the universities. Subsequently, as a supervising mechanism, universities submit written reports to the ministry quarterly comparing the plan and achievement quantitatively. For instance, the number of technology development projects planned to initiate, complete and transfer vis-à-vis the actual number achieved.

Hence, the relationship between MoST/MoSHE and the universities is outcome-driven, defined by the reporting relationship employed. The reporting component is not technical about the

[15] AASTU continued to use previously developed guideline
[16] *Birr* is the name of Ethiopian currency
[17] MoST/MoSHE represents the ministry based on the time it has authority over the universities
[18] It is a standardized quantitative reporting system by comparing plan and performance
[19] Each program is run by a vice president (VP) level under the president of the universities

technologies but inform the number of projects initiated, completed, and transferred (F2, F6). The legal accountability and reporting relationship manifest an agency relationship (Lane & Kivistö, 2008). However, another overseeing ministry to universities, the Ministry of Finance (MoF)[20], shares the universities' relationship with MoST/MoSHE in terms of financing.

MoF and universities: While establishing the two S&T universities, the Council of Ministers also approved the budget for the operations of the universities. The MoF has been overseeing the disbursement and budget utilization based on programs of the universities (F1, F4). Since the budget was approved in 2015, the MoF has released similar budget level, with minor fluctuation based on national budget changes (A1) for the subsequent five years, regardless of the budget amount utilized (see appendix 1). According to one official (A1), the MoF makes budget adjustments every five years based on the previous years' budget consumption (see Appendix 1 the budget drop in 2020/21 from the preceding year budget).

As a result, the funds were not routed through the supervising Ministry (MoST/MoSHE) overseeing the activity and operation of the universities but directly by MoF based on program category (i.e., research, teaching, administration, community service, and technology transfer)[21]. Moreover, MoF has agencies overseeing budget utilization and procurement by issuing various "directives, rules and regulation" (A1, A3).

The first of these agencies is the Public Procurement and Property Administration Agency (hereafter referred to as the procurement agency), in charge of introducing rules and regulations for the procurement process and controlling their implementation (A2, A3). The procurement agency supervises and audits procurements and property administration of federal public institutions, including universities (A2, A3). The second is the MoF's Office of the Federal Auditor General (OFAG) (hereafter the auditor) oversees *financial spending* in all federal institutions, including higher education institutions (A1). According to the auditor's office establishment proclamation, one of its responsibilities is to "ensure that all receivable money and property of the federal government are used properly in accordance with the federal laws and regulations" (OFAG, n.d).

[20] Pre 2018, it was called the Ministry of Finance and Economic Development
[21] Research, community service, and technology transfer programs are separate programs for budget allocation and reporting under the same vice president.

National level ministries and university level internal actors

One of the most important contexts for this research is the existence of two separate supervising ministries for the operation of the universities and financial accountability. As a result, according to officials (A1, F3, F6), it is customary for universities, including the two S&T universities, to prepare separate "activity reports" and "financial reports" to respective ministries. Based on a hierarchical and legal relationship (Kivistö & Zalyevska, 2016), MoST/MoSHE is a principal for "operational activity" of the universities, which are agents, including technology development. TTOs are responsible for reporting technology development and transfer performance to the ministry (Most/MoSHE) via the top management.

MoF also has units within universities representing their "interest." Universities' finance and procurement directorates enforce the MoF's and its agencies' rules and regulations and are audited as part of the process. Such a control and audit relationship (Eisenhardt, 1989; Shapiro, 2005) makes the two universities agents in executing the directive of the MoF within the university on the process of utilizing financial resources for the operational activities. The finance directorate office of universities executes the MoF's rules and regulations and is audited annually by the auditor (A1). Moreover, the finance directors of universities make a regular financial report through an online system called IBEX (A1). It should also use MoFs' budget item codes (see appendix 2) to prepare a budget breakdown for each program in the universities for a budget planning (A1) and report back, accordingly, which is line-item budgeting (Newman, 2013). The same relationship exists between the procurement agency and procurement directorates of the universities (A2, A3).

The following section addresses how the "dual" supervisory authority influences internal technology development actors' interactions. The relationship analysis in the following section is carried out at the backdrop of two national level principals and their influence within the universities. First, the technology development procedure was analyzed to identify the internal actors (i.e., within universities) participating in the technology development process.

4.2.Technology development procedure and actors

This section gives a process level (Creswell, 2007) context for the study. This is vital to comprehend the subsequent data analysis, identifying principal-agent relationships within the universities. Both universities conduct technology development programs under the mandate of

TTOs. Based on the interviews with TTOs' officials and project developers' explanation of the practice, the technology development procedure is identified[22] (see figure 2)[23]. The process outlines both the actors and how the technology development is managed in the two S&T universities.

The procedure follows:

First: both universities' technology development processes begin with TTOs' semi-annual "call for project proposals (see figure1) open to academic Staff.

Second: Academic Staff members interested in participating submit proposals to their respective departments, which collect and pass it to schools. Projects are evaluated at the school level by an ad-hoc evaluation team (hereafter peer evaluators), facilitated by schools in ASTU and the Centers of Excellence in AASTU (see figure 2). If the projects are approved, the peer evaluators send them to schools to be sent to TTOs.

Third: the schools forward the selected proposals by peer evaluators to TTOs for further evaluation. If rejected technology developers are notified by the schools in ASTU and the excellence center by AASTU to project initiators.

Fourth: TTOs make a budget evaluation and adjustments, if any. TTOs then forward a copy of the final selected proposals, which are part of the contract, to the vice president for research and technology transfer. Moreover, a signed contract between the TTO and academic staff accompany the proposals for the vice president to sign on the contract at the university level (i.e., there is no project evaluation at this stage). If projects are rejected at this stage, TTOs notify the project initiators.

Fifth: Copies of the final proposals, signed contracts, and letters to commence the projects are distributed to the universities' finance directorates by the vice president's office.

Sixth: three activities occur concurrently in this step after the project is launched or during the technology development process. First, the academic staff (i.e., technology developers) initiates the project's activities by requesting part of their budget from the finance directorate and procurement needs from the Procurement directorate. At the same time, the technology developers begin to work on the project and provides regular progress reports to TTO.

[22] This procedure represents the actual procedure practiced, and there are minor deviations from the procedure written in the TT guideline document of the two universities.

[23] The numbers in figure 2 represent the number on the steps or procedure.

Additionally, a progress report is compiled by TTO and sent to the vice president for research and technology transfer office (hereafter vice president office). The vice president office in turn forwards it to the ministry (MoST/MoSHE) along with other units' reports under the office regularly.

Seventh: After completing a project, the academic staff will submit the final project report to TTO.

Eighth: TTO will forward the final project output for peer evaluation to schools at ASTU and Centers of Excellence in AASTU.

According to the procedure, technology developers, peer evaluators, finance, and procurement directorates, are all direct participants in the technology development process with decision-making capacity. Meanwhile, the vice president's office, schools, and department play a supportive role than decision making in the process. An explicit written contract establishes an agency relationship (Auld, 2010; Gulbrandsen, 2010). Hence, the relationship between TTOs and technology developers makes the former a principal and the latter an agent. As a result, it is critical to examine the agency relationship between supervising ministries and universities and between TTOs and technology developers, including their goals. The relationship between the remaining actors, including the finance and procurement directorates and TTOs, is addressed in *the features of the technology development contract* section of this chapter.

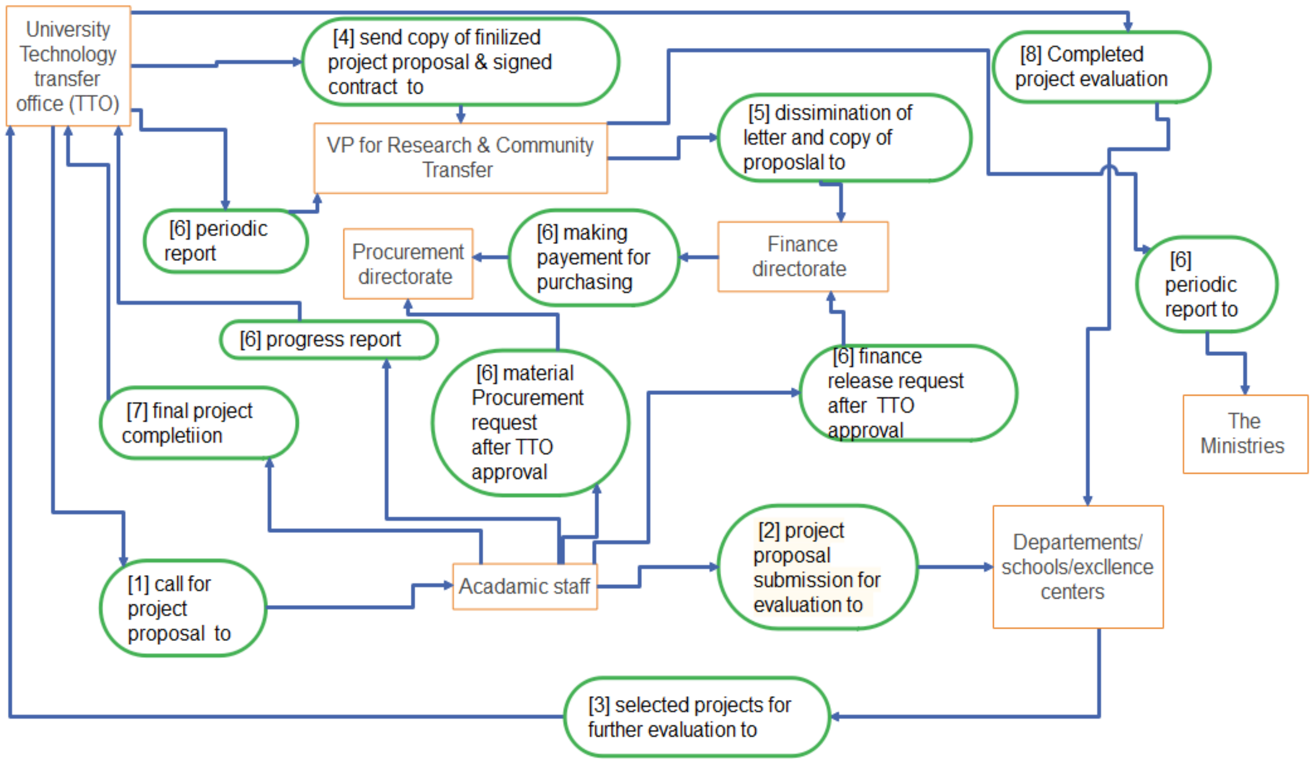

Figure 2. Technology development process in Ethiopian S&T universities

Note: the technology development procedure is developed based on the practice of the universities
Represents activity/decision by the preceding actor, and the numbers represent the flow of activities
Represents the actors involved in the technology development process

4.3. Goals of actors in technology development

4.3.1. Goals at university and ministry level

The relationship between the ministry (MoST/MoSHE) and the universities is founded on the institutional mission, as stated by officials who participated in this study (F4, F6). This is consistent with Friedman and Silberman's (2003) assertion that a written mission statement serves as a proxy for the principal's goal. As such, both universities' mission statements include components on technology development and transfer, reflecting the universities and ministry's shared goals for the technology development program.

ASTU, for example, claims in its mission statement that it will undertake "demand-driven research and community service... providing innovative knowledge to support the nation's socio-economic development" (ASTU, n.d-c). AASTU's mission statement makes comparable commitments, which is "conducting applied research to support productivity and competitiveness of industries... serving as a center for knowledge and technology adaptation, innovation, and transfer" (AASTU, n.d-b). As a result, universities are committed to technology development and transfer to contribute to socio-economic development. By default, these universities' technology development goals are shared with the MoST/MoSHE, as the missions and strategic plans were written and approved with MoST involvement and continued under MoSHE (F4, F6).

It is critical to examine how the actors practice the program's shared goals to check if agents pursue them. In line with this, Kivistö and Zalyevska (2016) suggest that goals can be altered with time by the parties, even if a principal and an agent initially shared the same goal. As a result, participants were questioned about the actors' objectives in practice. As such, university officials reviewed the ministry's stated objective in practice. According to informant officials (F2, F5), the ministry (MoST/MoSHE) officials inquire about the number of "societal problems solved" and technologies "developed and transferred" during their communication and report requests. These stated interests reveal that the ministry's goal is aligned with the universities' written mandate through the mission statements.

Furthermore, the ministry's (MoST/MoSHE) goal regarding the two S & T universities' technology development program became apparent during the global COVID-19 crisis. According to the project developers involved in COVID-19 projects (see appendix 3) and official participants (F3, F5), MoSHE asked that the two universities to develop technology solutions to prepare the country for the challenge. As such, four of AASTU's and two of ASTU's COVID-19-related initiatives were launched in response to a request from MoSHE. These projects involve building ventilators, which technology developers highlighted as a big challenge in addressing COVID-19 due to their global scarcity. By delegating this responsibility to universities, the ministry envisaged that the universities would identify critical problems and develop new technology solutions to address national difficulties. This confirms the ministry's expectations conform to the mission statement.

Additionally, the official participants offered their respective thoughts on their university's technology transfer objectives. Accordingly, ASTU and AASTU officials stated that developing "locally valuable technology," locating an industry that could "produce the prototype for dissemination," or "disseminating it through the university" are the goals of TTOs. As a result, through technology transfer initiatives, the universities' objective and by extension, the ministry's goal is to see new technologies reach industry and contribute to socio-economic development. However, further examination of the challenges surrounding TTOs and the technology development process in universities revealed a departure from the shared goal in practice.

Goals in practice: University level

The types of technology development projects preferred for funding by TTO officials, in general, were crucial pieces of information gathered. According to one TTO official in AASTU (F5), it is desirable to choose "technology projects that are not sophisticated, do not require a large budget, and can be completed within a year." He proceeded by stating that one project proposal was "rejected" at the university level owing to its "complex nature and high budget demand. This is despite the fact that the concept was connected to an environmental issue, one of TTO's priority areas. In ASTU, a TTO official (F3) responded to the same subject by stating that funding is better prioritized for "technologies that utilize local resources as input" and "viable projects that can be completed in a short period." Additionally, officials highlighted that such criteria will be utilized in the future to select projects at the TTO level, during the budget evaluation, and were already used to drop at least one project in AASTU.

This specific preference on the scope of technology development projects were raised in light of the challenges associated with project management. The officials stated this plan as part of mitigating output uncertainties in the technology development process. The TTOs officials' plan limits the scope of the technology development initiatives. This undermines the universities' mission and the ministry's expectations for high-level innovation and technology development and transfer to address the need of the industry and society. Furthermore, the goal of technology developers for initiating projects was inquired in this study as they are agents of TTOs to identify their goal.

4.3.2. The goal of technology developers

Technology developers were asked about their motivation and objective for participating in the technology development projects. The interviewees emphasized the importance of “contribution” to society as their primary objective. One respondent (P7) used the phrase, “our learning is incomplete unless we (i.e., academic staff) solve societal and industry challenges through research and technology development." The goal of contribution was particularly stressed by technology developers working on COVID-19 projects.

The second most frequently mentioned goal of the project developers was "gaining knowledge and experience." As one participant (P11) explained it, "I gained sufficient experience, to help students with technology innovation idea, which is the most satisfying aspect of my job." Additionally, another project developer (P8) stated that his "ongoing relationship with students who work on projects similar to his" is a result of his experience in the technology development project. Such claims indicate that the skill and knowledge acquired in technology development helped the academic staff support their students. Similarly, some technology developers (P2, P4, P8, P9) also mentioned their goal to use the technology development engagement as a "learning platform" to establish "private business ventures" in the long run.

The third objective frequently mentioned goal by the technology developers was "financial gain" from the commercialization of the technology they developed. As one participant (P13) stated, the aim was to complete the project and pursue "commercialization, which will result in financial benefit." Additionally, the developers' motivations for submitting their project ideas to the universities' TTOs were elicited. The project developers choose their respective universities to disclose their proposal, first, due to the university's "financial capacity" to fund the projects. The second rationale was that "interacting and communicating" with other stakeholders, such as industry is "easier" via universities.

The goals of technology developers identified such as contribution align with the goal of TTOs about technology development in the universities. Meanwhile, the order in which technology developers listed their objectives does not necessarily reflect their primary objective for participating in the process. This is because respondents expressed their concern about lack of financial remuneration while excluding financial compensation as their primary objective. Additionally, the objective of applying the acquired knowledge and skills to establish a business venture and using universities to access the industry for commercialization adds to the "financial goal" as a significant objective of developers. Thus, the important take away from the response is that technology developers' stated goals include financial and non-financial goals. Moreover, lack of financial incentive for technology developers has a connotation in the relationship between technology developers and TTOs concerning budget utilization.

Budget utilization goals

The MoF applies line-item budgeting for universities, and technology developers also use line-item budgeting approach in their budget proposals. Items and activities eligible for funding are listed, and once approved; reshuffling the budget to other items is restricted. So far, the "conflict" about budget utilization and lack of incentive are affecting the technology development scope and process.

Until 2018, a budget item called "professional fee," a lump sum of money paid monthly for the project's duration, was an incentive for technology developers to participate in a technology development project. According to officials (F1, F6), the auditor's general audit report revealed that doing research and technology development in higher education institutions is part of "regular duty and workload." Hence, no separate payment is allowed. As a result, participation in technology development project was replaced by a three-credit-hour per week workload equivalent. The work overload is calculated by summing up all academic engagements per semester, including the technology development project, teaching, research project, and positions held. The only incentive allowed is revenue from the commercialization of technology developed, which has never been materialized since none of the technologies were commercialized. Meanwhile, during project selection, the evaluation of the budget proposal is carried out by TTOs, which manifested the difference in perception and action between technology developers and TTOs.

Even if a credit hour was fixed for technology developers, it has impacted the project duration plan, resulting in divergent opinions among TTO officials and project developers. The technology developers believe that TTOs usually reduce the technology development time plan perceiving that the project duration results in work overload payment for developers. As one participant (P3) put it, “my project was big, and I asked for two years project life.” However, TTO officials’ position was to reduce the time because it implies work overload “payment” for two years whenever there is an overload in a semester. Similar claims were raised by other technology developers (P3, P5, P6, P13). On the other hand, the TTOs’ officials assert they decide to reduce project duration plan in proposals when it is “exaggerated.”

Similarly, a sign of reshuffling budget by technology developers, which violates the financial rules, was also identified in the budget item called per diem. Per diem is paid for travel and accommodation expenditures for staying in other cities or locations connected to the project[24]. However, some technology developers have referred to it as the "only financial incentive" (P1, P4, P6, P8, P14) they have in doing the project. Since the budget covers the cost and not financial benefit, it implies budget diverting against the budget utilization regulation.

In conclusion, the disparity in goals between principals and agents has an effect including moral hazard and necessitates measures to close the gap (Van Slyke, 2007; Kivistö, 2005; Bergen et al., 1992). The tendency of TTOs to drift from the mission of the technology development by limiting the scope of the projects, in practice and as a plan, has a cause and implications. The potential agency problems emanating from information asymmetry and goal conflict are presented in the discussion chapter of this paper.

4.4.Actors in selecting projects and technology developers

4.4.1. Delegation of the project selection mandate

In both ASTU and AASTU, academic staffs as peer evaluators, on behalf of TTOs, are delegated to evaluate project proposals submitted. The rationale given by TTOs' officials was that academic staff members possess the "knowledge and skills" necessary to carryout professional assessments and screening projects. Additionally, one official (F6) explained that "competent evaluators" not only assess the project but also recommend ways to "improve" it. This rationale is in line with mitigating information asymmetry (Shapiro, 2005; Eisenhardt, 1989) during the project selection process. Nevertheless, it is worth noting that in both universities, the peer evaluators are not selected based on education, research or experience and rank seniority compared to the project developers. They are selected based on "relevance of educational background" to the project they evaluate according to official interviewees (F3, F6).

One of the challenges of a principal in an agency relationship is information asymmetry during the selection process (Fleisher, 1991). The following section analyzes the actors involved in the selection process, their relationship, and the associated information asymmetry.

[24] See the contract between TTO/finance and technology developers' section of the analysis and result chapter for details

At ASTU, the primary responsibility of departments is to collect project proposals from technology developers and submit it to schools. Schools organize an evaluation workshop at the school level by requesting departments to send “relevant” peer evaluators (F1, F2, F5). In AASTU, departments play the same role, except Centers of Excellence organize the evaluation workshop at the school level instead of the schools. Meanwhile, project proposals have both a technical and financial component. During project evaluation, the officials and technology developer participants in this research unanimously agreed that the peer evaluators generally emphasize on the projects’ “technical component” than the finance section. This is as a norm, since there is no formal limitation in their mandate of the proposal section they evaluate. Furthermore, according to officials, the selection process considers projects and not the personal traits of developers (F2, F5).

In order to examine the information asymmetry, how well peer evaluators know and understand the technical details of projects during project evaluation was investigated. However, peer evaluators are not permanent and are formed as ad hoc teams to review projects on a volunteer basis. They were not interviewed in this study due to the lack of a comprehensive list record of evaluators. As a result, various approaches were utilized to explore the issue, including technology developers’ experience.

The participants' experiences on peer evaluators' "technical capacity" and their contribution to improving their project during the evaluation were mixed. In ASTU, participants stated that even though the assessment was "beneficial," the evaluators' level of expertise was "incomplete." Three participants (P2, P3, P5) described how the peer evaluators focused on the "proposal writing format" more than the "technology" itself due to the "lack of experience on the technology development project." Another participant (P1) shared a similar perspective, explaining that even though the evaluators had "close technical knowledge," his project necessitated "a particular skill" that the evaluators lacked from experience. Meanwhile, only one project developer (P8) stated that evaluators were "critical to significantly improving the project technically." Other developers (P6, P8, P9) asserted their project idea was "new," and evaluators focused on scrutinizing the benefit of the project to the potential users than the detail technical features of the project. This research attempted to check if peer evaluators rejected projects in ASTU so far, and none was identified.

In AASTU, one participant (P13) stated that the “comments made during the assessment process were important in enhancing the project.” For the COVID-19 related projects, the technology developers recalled the “debates and passionate participation” of staff during the evaluation. Few projects were “rejected” and deemed “infeasible,” according to officials (F5, F6). Two projects were accepted for funding even if they were the same technology ideas with different technical approaches to develop them.

One participant (P11) described his experience by stating, "some peer evaluators and staffs labeled my proposal technically impractical." The developer further explained that he "refined the concept" and explained the project's viability to the evaluators in a subsequent evaluation time, and eventually, the project was "approved.” The AASTU project developers described the evaluation process as "engaging" and "critical.” As Ouchi (1979) described, this approach resembles clan socialization because of the comprehensive participation of staff members in evaluating projects to ensure attaining the outcome.

One conclusion drawn from ASTU’s practice is that the asymmetry of “technical” information exists from the evaluators’ side while evaluating projects because of knowledge gap. In AASTU, additional information was needed to conclude technical information asymmetry due to the specific nature of the projects; COVID-19. Rejection of some projects also indicates the "know-how" of peer evaluators in the selection process. Furthermore, more scrutiny was required in ASTU to account for a complicating element, which is the assertion that some peer reviewers were not committed (P1, P3) to evaluate project proposals critically. Similarly, officials (F1, F3), stated because peer evaluation participants are volunteers with no "incentive," their commitment to assessment was "less." Hence, a lack of contribution to project improvement in ASTU could be a lack of commitment on the peer evaluators' side.

Hence, further analysis was made on the technical gap in the know-how of technology developers’ during the project planning compared to the execution phase as a proxy to measure the peer evaluators’ know-how. This is based on Johnson's (2011) suggestion that technology developers have a higher understanding than project evaluators at the early stages of a technology development projects. He also asserted information asymmetry for project evaluators is high at early stage. Hence, evaluators may not know the technical deficiency technology developers commit if they fail to recognize it during project proposal evaluation for selection.

Technical Know-how of technology developers

The project developers were asked about the technical comprehension of their project during the proposal writing process compared to the implementation phase experience. Four of the project developers (P1, P4, P7, P13) asserted that “the technical detail” in the proposal went as planned during the technology development or implementation process. They, however, added that “minor changes and adjustments” were made to the technical features of their project while developing them. The IT and software development projects (see appendix 3) further explained that standardized “technical procedures” of developing the technologies are embedded in the profession. Technology developers of this category asserted that the technical effectiveness is tested after the projects are completed with the involvement of the technology user.

Projects attempting to replicate imported technologies and improve existing local ones stated their experience too. They came across "significant" technical know-how, skill, and information "gap" while working on the project, which were not considered during the proposal development (P2, P3, P6, P8, P11, P12, P14). To quote one participant’s explanation of his experience (P14), “it was technically challenging to replicate the technology.” The participant further stated that the “lack of expertise on materials” was the bottleneck while developing the technology. Likewise, another participant (P6) said that “the project tested my ability to translate theory into reality.” The most frequently cited gaps were a lack of experience and the know-how of “input materials, components, and their properties” to develop the prototype technologies. These experiences of technology developers are illustrative of the fact that they had skill and know-how gaps during the technology development proposal writing. The relevance of this for information asymmetry is that the project proposal evaluators could not “capture” the knowledge and skill gap of project developers or contribute to its improvement during project proposal evaluation. The gaps were identified by developers themselves as challenges during project execution.

As it was mentioned, the selection of peer evaluators does not use skill, research experience, or seniority over technology developers as criteria; instead, the closeness of the subject matter studied is used. Thus, the likelihood of peer evaluators possessing a better technical understanding of the projects than the developers, who understood the project better during implementation than during proposal formulation, is low. This assertion is strengthened by the fact that the current technology developers are "pioneers" in developing practical technologies in the two universities, and the peer evaluators are inexperienced in the area. Hence, "technical" information asymmetry[25] is apparent. Once peer evaluators evaluate the technical features of the proposals, they are sent for further evaluation to the TTO office at the university level.

4.4.2. Project evaluation and selection at TTOs

The university level assessment applies to evaluations conducted by the TTO officials and, on occasion, with the participation of senior management[26]as guests at the Vice President level (F2, F6). All ASTU and AASTU officials agreed that the university-level project evaluation's focus area had been the "budget" section of the proposal. The term budget refers to the budget breakdown proposed by technology developers to execute the project.

The specifics of budget evaluation of projects are highly influenced by the financial rules and regulations issued at the national level by MoF and its national level agencies. Generally, officials assert that the financial rules and regulations have been "tightening" (A1, F6) for university programs. For example, before 2017/18, project developers could pay for car rentals and material purchases directly from their budget, but these were prohibited[27], by the auditor's general suggestion, after "audit" findings (F1, F6). Similarly, the professional fee, a lump sum of money paid as an incentive given for participating in a technology development project for developers, was abandoned at the same time, which will be discussed latter.

As a result, since 2018, material and service procurements for technology development are processed through the procurement directorates of the universities (A1, A2). The procurement process is governed by national statutes and rules published by the procurement agency (A2, A3). The procurement procedures also have an impact on the process of technology development and its outcome. According to one official participant (F2), when technology developers “submit a budget for material purchase; we approve it without much concern because it is processed via the university's procurement system" for projects initiated after 2018.

However, one budget item, *per diem, is* still directly spent by technology developers, which is critically seen during the project evaluation at the TTOs level. Per diem is a budget item that covers technology developers' travel and accommodation expenses concerning their project.

[25] Technical information/know-how asymmetry refers to the understanding level about the technology since what is evaluated is the “project,” not the personality of technology developers
[26] In COVID-19 projects, senior management participated in project evaluation workshops as a guest
[27] This regulation governs all projects initiated by academic staff, including research and community service projects

According to one official (F3), "we evaluate per diem critically to determine if certain travels to other locations are necessary, and the number of days proposed for travel is reasonable." Similarly, another official (F5), phrasing it in a roundabout way, claimed that "so long as the money would not end up in the technology developer's pocket, budget for per diem is allowed." The unique characteristic of per diem budget item is *cash* is provided directly to technology developers to make the expenditure from the budget. Moreover, there is no proof of expenditure issued from the third party like purchasing materials. Since there is no follow-up method to "check" if the "cash" is utilized for the purpose, it is intended for. The TTOs officials try to minimize "misuse" during the project selection through "critical" evaluation. This is because TTOs do not observe the "action" of the agent while spending the budget, which creates information asymmetry (Petersen, 1993). Hence, this indicates how the TTOs officials try to mitigate the challenge of information asymmetry they face during the budget spending. However, this has its implication for the project outcome.

All technology developer participants, but one (P12) reported that as high as to half of their initial budget was reduced during the TTO-level budget evaluation. According to the respondents, most budget reductions were achieved by lowering the number of prototypes planned for development and data collection and project implementation sites. As one developer (P4) put it, "I reduced the number of cities originally planned to collect data from," this in effect also reduces the per diem budget and duration of the project. Moreover, TTOs also usually reduce projects' life from the proposed time, which is discussed in detail in th*is* chapter's *budget utilization goals* section. Additionally, officials at both universities stated that if there is disagreement about the budget amount, the project will be dropped from funding (F2, F3, F6), as has occurred at least once in AASTU due to technical "complexity" and high budget level. After university-level evaluation and approval, the technology developers enter a contract with TTO.

4.5.The features of the technology development contract

The contract type and the agency relationship of additional actors are analyzed in this section. A contractual agreement ties the relationship between TTOs and technology developers in the two S&T universities. An approved project proposal is part and parcel of the contract, on top of a written contract between the TTOs and technology developers in both universities. Both AASTU

(VPRTT, 2013[28], P 23) and ASTU[29] (OCSTT, 2015, p.43) guideline documents specify the role and responsibility of the technology developer in a written contractual agreement. The contract type is explained using the stipulated articles of agreement and based on the discussion with TTOs' officials as follows.

[28] AASTU uses the same document developed before 2015 to govern technology development
[29] The same articles govern both community service projects and technology development projects.

Table 3 *TTOs and technology developer's contract articles and contract type*

Contract article in ASTU & AASTU	Contract type
The project initiator [technology developer] is responsible for undertaking the project according to the schedule stated in the project document and finalizing it (ASTU)	These articles refer to the outcome-based contract since the technology development output to be evaluated based on the output and time targets set in the project proposals (Siegel et al., 2003).
Carry out the project according to the terms and conditions set in the agreement (AASTU)	
The initiator is responsible for submitting progress reports and a final report within 15 days after the completion date of the project (ASTU)	Monitoring of projects is based on written report submissions by technology developers.
Periodically submit progress, final and financial report (AASTU)	
The initiator is responsible for paying back the sum of the expenses, which are not evidenced by the acceptable documents and unused funds (ASTU)	These articles refer to behavior-based control on financial utilization since it is monitored through rules and regulations (Schillemans & Bjurstrm, 2019) cascaded from MoF. The articles depict legitimate budget utilization methods and the consequences of failure to produce valid proof of expenditure documents by the technology developers.
The initiator will be accountable if he/she fails to justify the financial expenses used (ASTU)	
Be responsible for the proper utilization of funds allocated (AASTU)	
Present valid document on utilized fund before releasing the subsequent budget (AASTU)	
Abide by the financial, administrative proclamation of the Federal Government of Ethiopia and directives of the Ministry of Finance (AASTU)	
The initiator is obligated to demonstrate the project's outcome equivalent to the funds utilized in project implementation/progress (ASTU).	These articles represent an outcome-based contract and the evaluation of project outputs (see Siegel et al., 2003). ASTU's article explains that budget utilization is equivalent to project progress (i.e., the full utilization represents project completion).
The initiator should present the [research] output in the university[30] (AASTU).	

*Source: the contract articles are taken from the community service office and Technology Transfer (OCSTT, 2015) for ASTU, Vice President for Research and Technology Transfer (*VPRTT*, 2013) for AASTU. The contract types are categorized based on discussion with officials on the interpretation of the contract articles in practice*

[30] The same contract articles govern both research projects and technology development projects

The contract articles in both universities address “financial accountability," "timely completion" of projects, and the need to deliver the "output” of the project. As such, the contract governing the technology developers and the TTOs relationship reflects the supervisory ministries' (i.e., MoST/MoSHE and MoF) relationship with the universities. The following section discusses how the contract is executed from the project developers' and officials' perspectives, explain the additional actors involved, and their relationship.

4.5.1. The contract between TTOs and technology developers

The project developers are expected to generate outputs that are consistent with the project proposals' “targets” and “objectives” of output and time specified (F1, F3, F6). The setting of measurable targets implies an outcome-based contract (Schillemans & Bjurstrm, 2019). Contract articles related to this specify the need to produce the output of technologies developed. The contract article of ASTU states the technology developer is “obligated to demonstrate the project's outcome," and AASTU's asserts the need to present the final output to state the same (see table 3). One official stated that if project developers fail to complete the project when the budget is used up, they are expected to complete the project "at their own expense" (F2). The complete utilization of a project budget signals the completion of the project; hence the output of the project is expected from technology developers, agents, by the TTOs, principals.

However, the contract also encompasses reporting obligations on the progress of the project. In both universities, the technology developers regularly present a written report to their respective TTOs, including the project's status and budget utilization (F3, F5). As officials noted, there is no technical evaluation as the project progresses, and the project developers' written report is accepted as it is. Technology developers and officials interviewed agreed that even if progress reporting requirements were in place, they were not consequential, and no technical evaluation to verify the “actual” progress was conducted on any of the projects. According to many technology developers, the progress report is usually required when the TTOs compiles a report to send it to MoST/MoSHE.

However, after the first phase of the released budget[31] is fully utilized, it is mandatory to settle the expenditure with the involvement of TTOs and finance directorates of the universities. This

[31] The budget request for finance and procurement is based on, usually, 2-3 phases during the life of the projects

will secure the release of funds for the subsequent phase, according to TTOs' officials and finance directorate officials. Hence, the financial utilization report is more critical as a monitoring system of budget utilization. The execution of contract related to budget utilization involves finance directorates beyond TTOs and technology developers.

4.5.2. The contract between TTOs/finance and technology developers

Most of the contract articles in ASTU and AASTU specify the financial utilization accountability of technology developers (see table 3). The finance directorates of the universities monitor compliance with the rules and regulations in the budget utilization of projects in the universities (A1, F5). According to a TTO official (F1), the finance directorate "wields considerable influence," and their aim is "not opt-out of financial regulations for fear of damaging the university's image." However, the financial elements of the contract are signed between technology developers and TTOs, not directly with finance directorate.

Officials (F1, F2) and project developers (P1, P2, P14) discussed how developers' budgets are typically released to illustrate how financial control is carried out. TTOs are responsible for approving the project budget proposed by technology developers during the project proposal evaluations. Once approved, the developers may not change the items listed in the budget plan, indicating line-item budgeting (Newman, 2013). Changing it requires a "lengthy" administrative procedure, according to TTOs' officials. While the technology development is ongoing, the technology developers need to present budget utilization reports and project progress reports when the budget of one phase is fully utilized to get the next phase budget released (F1, A1, F5). TTOs contribute to this process by checking the budget request of a project developer (i.e., for budget release and material purchase) against approved budget items during the project evaluation.

The implementation of financial accountability listed in the contractual agreement is more instructive as per the experience of technology developers. One project developer stated (P2) his experience with an item he purchased to replace another item initially listed in the proposal submitted to "improve" the quality of the project. This was because he found out better, and at the time (i.e., pre-2018), technology developers were able to procure materials. However, the expenditure was not accepted by TTOs and the finance directorate because the item was not listed in the project proposal. The developer went on to say, "I explained the necessity to substitute the item to enhance the quality of technology and requested the TTO to verify that the component was purchased and assembled in the prototype being developed." Finally, "it took months and the involvement of senior management to allow the budget reshuffling and to continue the project." Like the relationship between the MoF and the universities, the TTOs enforce behavior-based contracts on finance utilization of technology developers. Meanwhile, it is vital to see the role of the finance directorate in this process.

The finance directorate and TTOs have no hierarchical, legal[32] or written contractual relationship regarding the process of finance utilization control. TTOs and administrative officials interviewed stated that, TTOs are autonomous and responsible for approving the initial budget plan of technology developers so long as the budget item is within the eligible list of allowed budget categories. The second is approving technology developers' budget and procurement requests and before passing them to the finance and procurement directorates, respectively. If TTOs approve budget items that violate rules and regulations, the finance directorates correct the problem. For example, when MoF introduced a regulation removing professional fees in 2018 from budget items for projects, technology developers at ASTU included professional fees in the budget proposal. The TTO approved it because the new regulation was not communicated to the TTO. The finance directorate returned the proposals for correction. However, there is no legal, reporting, or contractual relationship between TTOs and the finance directorate to suggest an agency relationship. However, both engage in an interrelated and joint[33] of control on financial utilization of technology developers for the projects; hence the contract fulfills the need of the finance directorate. The financial utilization control uses rules and regulations consistent with behavior-based contract and control (Kivistö, 2005), which characterizes the relationship between technology developers and TTOs/finance directorate.

Finally, it is important to understand the distinction between finance and procurement directorate in relation to TTOs. The items and services that can be purchased for projects and how the budget money is spent are guided by finance rules and regulations. Hence during the budget proposal TTOs ensure the rules are not violated and finance directorates double check it. Meanwhile, the procurement directorates undertake the procurement of materials when the TTOs

[32] Finance and procurement directorates are under the vice president for administration.
[33] TTO/Finance and TTO/management is used when TTO works in collaboration with each, and information are shared

approve the procurement request by technology developers. TTOs approve requests for items in the list of the initially approved budget proposal. Once the procurement directorates receive the approved request, they conduct the purchasing based on the rules and regulations and procedures set by the procurement agency at the national level. For the money spent directly by the technology developers, TTOs and finance directorate control the developers based on finance rules and regulations. Hence, the finance related contract and its execution is handled by TTOs and finance directorate.

4.6. Evaluation of the technology development Outputs and measurability

The relationship between technology developers and TTOs reflects the reporting relationship between MoST/MoSHE and the university. The TTOs report the number of projects initiated, completed, and transferred compared to their plan. This implies outcome-based contract since measurement is possible (Ferris & Graddy, 1998). Similarly, the contract between TTOs and technology developers constitutes an outcome-based contract concerning technology development outputs (see table 3). The effectiveness of outcome-based contract is dependent on the measurability of outcomes (Bergen et al., 1992; Eisenhardt, 1989). The practice of technology outcome measurement in the two S&T universities' TTOs was analyzed. Technology developers of completed projects (see appendix 3) asserted that the final technology prototype evaluation was conducted by peer evaluators. However, the evaluators were not necessarily those who evaluated their proposal during project selection. The process of selecting evaluators of projects is similar with the process of selecting project proposal evaluators. Hence, the practice was shared by TTOs' officials and technology developers who passed through the process. According to officials (F2, F5), the final prototype is supposed to be evaluated against the "target set" in the project proposal, the practice technology developers also confirm.

Accordingly, technology developers set their output measurement parameters in the proposal. The outputs' target of projects included under this study can be divided into two categories for this research purpose, based on similarity in the measurability of output based on discussion with developers. The first one is goals that could be technically measured. The second one was goals that could be measured as an "impact" of the project. The first category includes minimizing energy utilization, lowering carbon emissions, attaining processing capacity per specified time of a machine labeled with measurement units. They are described as "measurable" or "observable" targets by the developers. This indicates the possibility of measurability of outputs for outcome-based contract (Ferris & Graddy, 1998).

Meanwhile, in addition to technical targets, most of the projects claimed that they included parameters such as developing "low-cost technologies," and "import-substitute technologies." Moreover, technologies with end goals of saving hard currency, creating a specified number of employment opportunity and technologies with "customized functions" to local needs are additional goals to the measurable targets. These objectives relate to project impact. Ideally, the impact-related targets can be assessed well after the technology is transferred to the potential industry or user according to developers. For example, attaining low-cost technology, saving foreign currency, or creating employment opportunities can be tested if technologies are transferred and commercialized. Meanwhile, IT and software development project developers (see appendix 3) mentioned that their profession has its standard for project target setting and measuring project output. Particularly, they claimed that the users of the technology test the final output effectiveness.

Meanwhile, attaining the targets of the project outputs was assessed further. Two project developers at ASTU asserted that their projects were ready for direct mass production and commercialization of the prototype (P2, P8). Two project developers (P2, P6) reported that even though their projects were designated as "complete" officially, "technical improvements" are still required. Three COVID-related initiatives at AASTU were categorized as "complete" since they have exhausted their budgets, but officials and project developers acknowledge that "substantial" improvement is required, and the prototypes are not ready to perform their intended purpose or function. As such projects were not meeting their target.

The study identified that the projects' output evaluation had created disagreement between peer evaluators and technology developers. Because of the outcome uncertainty factors, the targets set by technology developers in their project proposals were not usually met. Hence, the criteria to evaluate projects were replaced by evaluating the "functionality" of technologies, making it subjective. As one developer (P2) puts it, "one evaluator insisted that his expectation about the function of the technology was different, and rework is needed." The developer further stated that the project was later accepted after "explaining the challenges encountered" during the technology development process. One official (F2) in ASTU also asserted that the TTO intervenes when "disagreement" arises between peer evaluators and technology developers on the outcome of projects in favor of the latter since the challenges are known.

The challenges in the measurability of outcome are explained by outcome uncertainty factors in the two S&T universities technology development process. Outcome uncertainty is usually high in technology development projects, which determines the outcome of a project (Rasmussen & Gulbrandsen, 2012). Hence, the outcome uncertainty variables that affect the progress and outcome of the technology development projects in the two universities' contexts were identified.

4.6.1. Technology development: outcome uncertainty factors

All technology developer participants in this study concurred that the significant outcome uncertainties during the project development were related to the finance and procurement process. Most developers also added technical skill gaps and external stakeholders' cooperation level as uncertainty factors they experienced. These uncertainty factors had an impact on the performance of technology development progress as well as its outcome. The uncertainties raised were categorized as follows.

Inaccessibility Imported purchase: Most technology development projects were prototypes, a physical output, built using materials and components. Meanwhile, one of the main consensuses among officials was that technology development in the two S&T universities should focus on utilizing "local resources." In ASTU this was raised as a criterion to choose project proposals in the future by TTO officials, a preference to projects using locally available materials. Meanwhile, in practice, some crucial components and materials for technology development projects were not found in the local market, even if their price were low and the quantity required was small.

According to procurement officials (A2, A3), international purchases are undertaken at the national level by the procurement agency on a periodically, semi-annually at most, to capitalize on low cost through "bulk buying." Meanwhile, technology developers stated that prototype development requires a limited quantity or volume of material and component items at a random time. Hence, the need of technology developers does not fit the international purchasing process through procurement agency from abroad. For instance, one project developer targeted to build "lighter" machine in weight for portability (P8), and another participant (P6) planned for a low-level power-consuming technology. Both, however, "failed" to fulfill the target because they could not get high-quality materials fit for their project target from abroad through procurement.

Inaccessibility to imported materials is a frequent stumbling block for many project developers working on the technologies with a prototype output (see appendix 3). This had a detrimental influence on "quality," undermining technology's intended output "targets" (P2, P5, P6, P10, P12). Meanwhile, two projects were paused due to the necessity of components that could not be found locally and need to be imported from abroad (P5, P9). The main impact of this uncertainty factor was stated as an adverse effect on technology output quality target, design, and project progress. This is an uncertainty factor since neither technology developers nor TTOs control the rules and regulations binding importing goods, which is governed by national level procurement rules.

Lengthy Procurement procedure: According to technology developers with prototype output (see appendix 3), a lengthy procurement process in the universities prolongs the time required to complete their project. This challenge is recognized, and rules and regulations are cited as a cause by procurement directorates. Procurement directorates officials (A2, A3) asserted that all procurements in universities should go through an open bid process as a guiding procedure set by the procurement agency. Accordingly, procurements should be advertised three times, and the call for open bid is canceled if there is a lack of interested bidders or if few bidders applied. Then the second in line of procedure is announcing "limited bid," in which only a few organizations are asked to participate. The third option is to use "pro forma," a direct procurement permitted if the item to be bought is less than a stipulated quantity and price. Besides, a price quote should be collected from at least three suppliers. As such, each kind of procurement, based on volume and price, has its own set of regulations and procedures stipulated by the procurement agency, as officials in the procurement directorate stated.

Moreover, the technology developer participants claimed that procurement delays were caused by the "procedures" and "bureaucracy" at the procurement directorates. Participants who were developing a prototype (see appendix 3) provided examples of materials that might be obtained from the market in a "small quantity at a low price" but were bought through a lengthy bid procedure at a "higher price" and "unnecessarily large quantity." Moreover, the procurement is processed “slow” at the procurement directorate according technology developers. The procurement officials (A2, A3) of the two universities asserted the reason for the delay in procurement was an “overstretched” workforce, and the time required to collect procurement needs from university-wide offices. This is because bulk buying is favored to minimize cost. Additionally, depending on the type of item, procurement requests can only be processed at the national level through the national procurement agency (for example, see appendix 4). Both procurement officials and technology developers agree that procuring services such as car rental is more convenient than procuring materials and components for prototype-based technologies.

In general, lengthy procurement procedure contributes to project delays and “incomplete projects” after consuming a portion of their budget for the technology development process (P5, P10). This delay made some technology developers (P3, P5, P9) consider “quitting” the project after a sizable percentage of the funds has already been spent. Another participant (P10) mentioned that the project was based on COVID-19, and the materials required were time-sensitive. Hence, the purpose of the project may diminish as procurement is delayed. As such, procurement delay causes project delay, while projects are time-bound, and on-time delivery of output is a part of contractual agreement (see table 3).

Inconvenience of procuring low-cost items: technology developers mentioned another recurring issue: the procurement of “low-quality” components to comply with procurement regulations demanding “least-cost” purchasing. This influences the quality of technologies developed. One technology developer (P6) shared his experience stating that “I needed to drop some of the items purchased by the directorate because the items would shorten the functional life of the technology.” Another technology developer (P9) stated that “price usually implies quality in the market,” and low price correlates with a low-quality item, which has a bearing on the target quality of the technologies developed.

Lack of flexibility to cover unexpected costs: One of the uncertainty factors raised was unanticipated costs, mainly related to experts working in workshops for technology developers, both inside and outside the universities. In the technology development process, the developers manage the need for workshops to develop their projects both in internal and external facility. According to technology developers, because both university and external workshops are typically scheduled around regular tasks, the workshops meet these needs during off-hours.

Hence, the experts supporting the technology developers usually need an incentive, which is not covered in a budget item, posing a barrier to the projects' progress (P3, P5, P6, P12, P15). Miscellaneous costs that could not be covered in the budget item due to lack of "proof of payment" from the market or budget items overlooked during proposal development were all challenges. This created inconvenience for technology developers to manage such unforeseen circumstances, adversely affecting its progress and quality (P2, P6, P8, P11, P12).

Lack of cooperation from external stakeholders and skill gap of external experts: technology developers interact with external institutions to develop technologies. Two project developers (P7, P13) mentioned that the "lack of cooperation" from external stakeholders was their biggest challenge, "hampering the realization of their project target." The developers could not find the data needed to develop the software they planned, which was critical for completing the project. As a result, one of the projects (P7) was compelled to shift the scope of data collection from a national to a regional level. Moreover, the project was originally scheduled for two months but ended up delayed for more than double the schedule as a result.

Moreover, some technology developers sought technical assistance from external industry; primarily due to lack of facilities in their universities' workshops and labs for their project need (P6, P12, P13). Nonetheless, the lack of skill, facility, and materials in these external workshops has posed uncertainty on the projects' outcome. After developing the project's design, one developer stated, "I went to a well-known public institution with nationally acclaimed facilities and technical expertise," and "the experts could not translate the design to the component needed." The developer went on to say this was due to a lack of "advanced equipment," "certain materials," and "technical precision" by the technicians in the facility. Similarly, another developer (P6) had visited various industries to make components for the prototype. The developer saw a "technical skill gap" to work on flexible design in these institutions. This had a bearing on target and quality of the projects according to technology developers' experience.

Technical knowledge and skill gap: technology developers explained their experience of the "technical" deviation during the project plan and execution (P2, P3, P6, P8, P11, P12, P14). As one project developer (P11) put it, "there were days when I spend a lot on a design and try to develop the technology practically, but the components misfit or show a low level of performance", and "I bump against my faulty technical assumptions." Other technology developers recounted a similar experience (P2, P6, P12). According to the developers, such problems impacted the project's progress and in meeting the target output.

Outcome uncertainty factors management practice

Technology developers raised concerns about the contract's incompatibility and their own experience of technology development deviating from the project's original plan. Technology developers contended that innovation requires "trial and error," experience, and continuous research to be effective due to the uncertainties in the actual technology development process (P2, P11). An outcome-based contract is applied to technology developers for technology development output, while a behavior-based contract is applied to their budget utilization for technology development. As such, the "rigidity" of line-item budgeting and equating of budget utilization with project progress and completion were incompatible with the characteristics of technology development, according to the technology developers. However, the technology developers and the TTOs' officials have their own approach in handing the outcome uncertainties.

Technology developers' approach: The technology developers have attempted to solve the uncertainty factors using various approaches. Using "social network" was mentioned as a major means to resolve the outcome uncertainty factors. For instance, some project developers tried to acquire materials they needed from abroad via expatriate staff in their university (P5, P6) and other social connections (P12), mostly paying for it from "their wallet" since such procurements are not reimbursed. Others used their network to get services in external workshops free of charge. One project developer (P6) stated that "fortunately, I studied with the technician who works in the organization I was looking for a workshop facility service from," and "I was able to receive the service in the manufacturing workshop readily." Others tried to directly "push" the procurement directorate purchasing personnel to "speedup" procurement using the personal connection and informal communication.

Officials' approach: the officials recognize the uncertainties in finance and procurement-related rules and regulations. One official (F3) remarked that "we can only write support letters to the directorates, MoF and the procurement agency for expedited procurement service and solving legal loopholes" (for example, see appendix 4). Nonetheless, ASTU's TTO officials argued a portion of the task of minimizing uncertainties should be on shoulder of technology developers. According to one official (F2), the developers want to “make procurement by themselves” and “wait” until problems are solved for them. According to the same source, some project developers “took a long time” before starting the projects or even “neglect” the project due to “small inconveniences.” Finally, the TTOs’ officials explained their plan of selecting “less complicated” projects with a small budget and using local materials to the end goal of making projects more manageable by “avoiding” uncertainty factors.

In sum, the uncertainty variables were making the project output targets deviate from the plan, and delay projects in the two S&T universities. This has its consequence on managing and effectively enforcing the outcome-based contract. As such, TTOs’ officials recognize the uncertainties and peer evaluators use other subjective metrics to measure the outcome, which results in "conflict" with the technology developers. TTOs also were mediating conflicts and accept project outcomes even if they failed to meet the target. This is because the TTOs recognize the uncertainty factors. Above all, the outcome uncertainties adversely affect the quality and progress of projects and the prototypes' readiness for transfer.

4.7.Transfer of projects

The technology transfer guidelines of the two S&T universities affirm that transfer of technology is achieved through commercialization, and it is the duty of the universities’ TTOs. According to AASTU’s guidelines, “the technology transfer officer reviews invention disclosure, conducts patent searches (if relevant), and assesses the market and competitive technologies to determine the invention’s commercialization potential” (VPRTT, 2013, P.15). Furthermore, the document states the commercialization approach involves “licensing to an existing company” or starting “a new start-up” (P15). A similar statement is used in the ASTU’s guideline to describe the same (OCSTT, 2015).

Yet, the status of current technology outputs is influencing the commercialization of technologies. Both ASTU and AASTU officials recognize the “technical gap” in the technologies that have been developed. According to one official (F5), “it takes time for the technologies developed to be the perfect outputs.” As such, technologies’ “low-level maturity” makes commercialization challenging to contemplate as per the officials (F3, F5).

However, some technology developers contend that the technology commercialization challenge is not only explained by inadequate maturity level of technology output. Two completed ASTU technology developers (P1, P8) claimed that the TTO's "effort" was "not adequate," even though they recognize a lack of suitable industry to take the innovations. There are two points of these responses from officials and developers relevant to this study. First, they prove the outcome uncertainties adversely affect the commercialization potential of technologies developed through poor output quality as asserted by Heslop et al. (2001). Moreover, since it is the responsibility of the TTOs, there are assertions by some developers that TTOs are not discharging their responsibility, implying moral hazard. However, commercialization of technology requires broader study by including internal capacity, external stakeholders, and suitable approaches (Rogers et al., 2001; Bozeman, 2000). Hence, transfer and commercialization require independent study, and it is beyond the scope of this study.

Chapter 5: Discussion

This chapter discusses the finding of the analysis and results in light of the theoretical lens and past research findings on technology development. As such, discussion is about giving meaning and using the finding from previous studies and literature (Drisko, 2005) and presenting the critical finding of the study (Gopaldas, 2016). As Drisko (2005) explained, context-based practices, limitations, and boundaries in the findings and interpretations are discussed. The theoretical framework (see figure 1) components are used to elaborate the interpretation of the findings.

5. Identification of actors, principals, and agents in technology development

In order to comprehend the actors involved in the universities' technology development program, it is vital to see it from national level actors first. The rationale is that the mission of universities is a part of a national policy initiative, which entails accountability to government entities (Marhl & Pausits, 2013) and is bound by a legal framework (Berghaeuser & Hoelscher, 2020). The agency relationships are established based on legal and hierarchical or control structures (Kivistö & Zalyevska, 2016; Fama & Jensen, 1983), dependency, funding, and reporting relationships, and written contractual agreements (Mahaney & Lederer, 2003). Meanwhile, the identification of actors in this study is limited to technology development since an agency relationship relies on a particular and defined decision-making issue (McGuire, 1988; Ross, 1973), which is technology development in this case. Any relationship among actors outside the technology development program or a broader scope of actors' relationships is excluded.

National level actors

The actors, including principals and agents of two S&T universities, were identified based on their relevance and responsibilities in the technology development process. MoST/MoSHE, at a national level, is the principal for universities' technology development programs and overall operations in a broader scope. The universities are accountable to MoST/MoSHE by proclamation (see, for instance FDRE, 2014), creating a supervisory role for ministries. As Lane and Kivistö (2008) illustrate, the accountability connection in an agency relationship can be on a legal basis through a proclamation and is characterized by an "oversight" connection (p.141).

The reporting system and content add to the relevance of the ministry in the agency relationship. The universities use a balanced scorecard reporting system, a quantitative reporting for each program in which research and technology transfer is one program. The number of technologies planned and developed, and transferred are reported, which directly reaches the ministry. TTOs send the report via the vice president for the research and technology transfer office of universities.

An agency relationship is also explained by resources mobilized. Braun (1993) argues that a principal spends resources for an agent to carry out the task given on behalf of the principal. In the two S&T contexts, an independent national entity, MoF, is responsible for funding the two S&T universities' programs, including technology development and transfer. Once the Council of Ministers approved the budget in 2014/15, MoF has been responsible for releasing the budget and monitoring "how the funds are utilized" by introducing rules and regulations, as principals to the universities' programs including technology development.

The availability of these two principals (I.E. MoST/MoSHE and MoF) at the national level wields its unique impact within the S&T universities with respect to technology development. As Shapiro (2005) and Waterman and Meier (1998) indicated, multiple principals complicate agency relationships, and this research has an empirical finding to support it. At the national level, the presence of two principals influenced the relationship among actors within the universities' technology development process.

University level actors

Within universities, the TTOs and technology developers enter into written contractual agreement, the latter to develop technologies on behalf of the former. Hence, as agents for TTOs, the technology developers are academic staff participating in the process because of their expertise. The written contract gives the principals, TTOs, a means to control the technology developers, agents, establishing a principal-agent relationship (Mahaney & Lederer, 2003) between the two actors.

The "complexity" of the agency relationship is manifested when actors try to enforce the performance of technology development and adherence to financial utilization rules and regulations at the same time. TTOs make decision in the approval of the technology developers' budget proposal. The finance directorates of the universities check if the requested budget violate the rules and regulations of MoF and its agencies. Practically, at least once, the finance directorate returned a “prohibited” budget item included by developers and approved by TTOs in ASTU. TTOs approved the request at the time since the change in regulation from MoF was not communicated to them. During the technology development process, TTOs control if the budget request by the developers is in line with the budget items and amount approved. During the project's progress, the technology developers need to present proof of expenditure to the finance directorate, and if rejected, the technology developer would pay back the money according to the contract.

However, there is no hierarchical, reporting, dependency, or control relationship between the TTOs and the finance directorates in the two universities. Instead, both undertake a "cohesive" chain of control in ensuring financial rules and regulations are not violated. The combined acts of TTOs and finance directorates make them what Kivistö (2007a) calls group level "principals" in the process of "financial utilization oversight" by technology developers. Hence, TTOs adhere to the financial rules and regulations over technology development activities when choices are encountered. There was no goal conflict identified in this research between TTOs and the finance directorates. Even if the two units are separate, in a structural hierarchy, both contribute to controlling the adherence to the rules and regulations of budget utilization, making them both principals as a group.

Meanwhile, the procurement directorate performs procurements according to applicable laws and regulations set by the procurement agency when technology developers submit requests through TTOs (see figure 2). TTOs send the requests to the procurement directorate after checking them with the approved budget plan. Technology developers depend on the directorate to get the materials and services they need to be procured. The dependency relationship indicates an agency relationship (Pratt & Zeckhauser, 1986). However, when technology developers state the procurement directorate delays the process, both TTOs and technology developers do not have the hierarchical and reporting relationship, hence no authority to control the directorates, which is needed in an agency relationship (Kivistö & Zalyevska, 2016; Fama & Jensen, 1983). This implies the absence of full agency relationships between the procurement directorates and other actors involved in the technology development. Nonetheless, the directorate decision-making adds to the uncertainty of technology development project outcomes.

The procurement directorate can be referred to as "other agency relationships" with regulatory and legal constraints that complicate an agency relationship according to Shapiro's assertion (2005, p.269). In this case, the agency relationship between the TTOs and the technology developers is affected by procurement directorates with their own agency relationship. It is critical to notice that the procurement and finance directorates report to a portion of the universities' top administration. However, senior management made no practical decisions to intervene, except communicating with ministries on challenges (see appendix 4). There was no practice whereby the top management made decisions on procurement delays or by changing rules and regulations as stated by officials and technology developers participated in this study. This is because the national rules and regulations are frequently referenced in relation to outcome finance and procurement uncertainties that extend beyond senior management's decision-making authority.

Meanwhile, in terms of organizational structure, TTOs and universities management, particularly the vice president for research and technology transfer office, have a hierarchical relationship. Nonetheless, TTOs are autonomous in managing the technology development process (i.e., project selection, approval, progress reporting, and final project output evaluation), which is the scope of this study. In the performance reporting process, MoST/MoSHE receives periodic TTOs' reports on technology development and transfer compiled with reports from all other units such as research directorates and excellence centers under the vice president. As a result, top management sends the compiled report of TTOs' and other units to MoST/MoSHE directly without changing the content. Hence, the ministry gets the direct report of technology development, combined with other activities of TTOs such as community service projects in ASTU and STEAM center in AASTU. Hence, the agents representing the university in technology development process are TTOs in this case.

The top management cosigns the contract along with TTOs representing the university, as a procedure, in a technology development program with technology developers. With the existing projects under study, there were two involvements of top management. The first is availing during project evaluation as a guest and, the second was in solving a dispute on the item purchased, which was not on the budget breakdown by a technology developer. However, there is no active control role of top management on technologies developed as the practice in the projects so far indicates. However, this assessment is based solely on technology development and has limitations in evaluating the whole relationship picture. Hence, there could be other tasks and decision-making processes of TTOs, which could show a broader agency relationship with top management, which is beyond the scope of this study.

Finally, TTOs delegate academic staff at the school level to evaluate project proposals and technology outputs after completing projects on behalf of TTOs. This entails dependency relationships, one magnification of agency relationships (Kivistö & Zalyevska, 2016; Fama & Jensen, 1983). However, there is no contract or hierarchical relationship (Pratt & Zeckhauser, 1986) between TTOs and peer evaluators. Hence, the link may not be concluded to constitute a "full" agency relationship. TTOs do not have control right over peer evaluators. This authority is important since TTOs' officials asserted some evaluators lack commitment during evaluation. Peer evaluators can be considered a "transitory" part of TTOs, not an agent with accountability, such as in case of lack of commitment to the task.

5.1.Goal and goal conflicts

Budget spending Vs technology development

Based on the report MoST/MoSHE seek, the goal of the ministry is to see "technologies developed and transferred," whereas MoF's is to see that financial rules and regulations are adhered to when funds are used for technology development projects. There is a goal conflict between MoST/MoSHE and MoF. The goal conflict has indicators such as prioritizing goals, as Rasmussen and Gulbrandsen (2012) stated. MoST/MoSHE "directs" the universities to contribute to economic development through technology development and transfer. On the other hand, MoF asserts that technology development can be carried out under the umbrella of "financial regulation restrictions" on spending projects' budget. This goal conflict in prioritizing necessitates discussing the original goal of forming the two universities for the technology development and transfer programs.

The budget approved by the Council of Ministers for universities was allocated to carry out the institutions' mandate, including technology development activities. Nonetheless, MoST/MoSHE evaluates universities based on the number of projects they planned and completed, overlooking the considerable budget available for additional and broader project initiatives (see appendix 1, the annual budget and utilization figures). On the other hand, the MoF monitors by examining how the budget is spent considering the rules and regulations for the designated program, technology development in this case. Hence, it does not evaluate the budget utilization level[34] from the total budget, even if the budget is not utilized at all. This is notwithstanding the minor[35] adjustments MoF makes every five years as a response to an unutilized budget.

Additionally, budget reductions made by TTOs during project selection to minimize "per diem" payment, by extension, could reduce the size and scope of the projects. As a result, TTOs chose to safeguard budget spending regulation over technology development objectives and outcome. Nonetheless, TTOs and top management are aware of the detrimental effect of finance and procurement uncertainties have on technology development goals and played a supportive role. As a result, TTOs and top management attempt to address supervising ministries about the challenges (see appendix 4).

The mission of technology development vs. manageability of projects

TTOs in the universities share a common purpose with MoST/MoSHE of "developing and transferring technology" to industry and society to address socio-economic agendas and promote development. This common goal is derived from written or strategic documents, as asserted by Friedman and Silberman (2003). Even if the TTOs and MoST/MoSHE had the same intent in written documents, as Kivistö and Zalyevska (2016) suggested in a normative study, the TTOs' as agents are diverging their goal. TTOs' officials assert the outcome uncertainties which resulted in delays and interruptions in technology development projects are the cause. TTOs' officials have been deciding to select projects with less sophisticated development processes, smaller budgets, and projects utilizing locally sourced materials to make project manageable. By focusing on the "manageability" of projects, this strategy will weaken the prospect of soliciting technologies proposed by developers to "solve industry and society related problems." This

[34] The budget is released quarterly from MoF to universities based on the financial report. If the budget is unutilized, MoF rotates it among federal institutions where there is a shortage (A1). Since MoF rotates an unutilized budget, lack of budget utilization may not be seen adversely by MoF.
[35] The budget reduction is minor and not to the level of budget utilization (see appendix 1).

finding is an empirical confirmation for the assertion by Kivistö and Zalyevska (2016) that agents' goals divert as time passes, even if the relationship starts from a common goal.

5.2.Information asymmetry

Information asymmetry is one of challenges in the actors' relationships in the technology development process. Information asymmetry occurs when a principal fails to ascertain an agent’s competence, secret motive, or behavior (Saam, 2007). This suggests the requirement for information before entering a contract, or in this case study, in the project selection process. Three scenarios of information asymmetry were identified in the technology development of the two S&T universities, in the selection of projects, during budget utilization and reporting content.

Selection of projects

In the two S&T universities, peer evaluation approach is used for project selection with the assumption that peers have a better understanding of the projects. Information is essential to identify the best agent in an agency relationship (Ferris & Graddy, 1998). Involving experts or TTOs hiring technically capable staffs for evaluation is the right approach according to Rasmussen and Gulbrandsen (2012) and Johnson (2011) for project selection process. Similarly, selecting the right scientists with knowledge and skill for technology development is vital, referring to input control in the control theory (Johnson, 2011).

During the project selection process, it is possible to assess the technical feasibility (Rasmussen & Gulbrandsen, 2012), commercialization potential of technology development project outputs (Gulbrandsen, 2010) as well as the agent's traits (Bergen et al., 1992). Peer evaluations at the two S&T institutions are primarily concerned with the project's technical feasibility. This selection process depends on the technical know-how and skill of technology developers (Johnson, 2011). However, technology developers claimed that peer evaluators lack the technical skill and knowledge to improve their projects during project evaluation, particularly in complex and multidisciplinary projects. This confirms the position of Kivistö and Zalyevska (2016) that higher education institutions engage in complex innovations that produce information asymmetry for those who oversee performances.

As a retrospective study, the study found that technology developers encountered a knowledge and skill gap between proposal development and actual technology development. This ascertains knowledge asymmetry among peer evaluators. The technical flaws were not "identified" by the evaluators during the project review stage but were uncovered afterward by technology developers. This goes along with Johnson's (2011) argument that technology developers have better know-how about projects at an early stage, creating information asymmetry for evaluators of the projects. As a result, the TTO's efforts to overcome information asymmetry in project selection through peer evaluation fall short of its objective in this context.

Budget utilization

The study also identified how the principals manage the potential information asymmetry on the technology developers' budget utilization. At the national level, various decisions have been made to shift technology developers' decision-making rights (i.e., on all project-based programs run by academic staff) and tighter control are put forth on budget directly spent by technology developers. The prominent example is when the procurement directorates took over the mandate to execute material and service procurement in 2018. One approach for a detailed control process is to make information available during the execution of a task (Schillemans & Bjurstrm, 2020; Fleisher, 1991). Accordingly, a line-item budgeting system used by MoF at the national level to control universities budget utilization in each program is also practiced within universities. The project developers are expected to give "complete" information of the budget breakdown, which is used to control the behavior of budget utilization. Changing the original budget breakdown (i.e., information) is faced with a lengthy approval process at best.

However, at the institution level, there are budget items retained under the expenditure mandate of technology developers after the 2018 shift of responsibility to procurement directorates. These items are per diem and duration of a project, which translates into workload and financial benefit in case of weekly workload exceeding the regular working hours.[36] However, the behavior or tasks of technology developers, such as the project activity schedule and the actual spending of the per diem budget are not monitored during technology development. Petersen (1993)

[36] Regular teaching workload is 12 credit hours per week. Engaging in research and technology development project is allotted three credit hours per week. If the sum of hours of all duties exceeds 12 credit hours, additional payment is given for the academic staffs

explained such scenario as information asymmetry because of hidden action. As such, the TTOs as principals could not observe the actions of expenditure and tasks the technology developers as agents do during the technology development. Hence, TTOs try to minimize the value of this budget item and project lifespan before getting in to contract as a selection process.

Reporting content of TTOs

TTOs' report to the ministry (MoST/MoSHE) combines the technology development and transfer sections with other operations, which inflate the number of technologies "completed" and "transferred." TTOs of ASTU combine it with the community service and AASTU with student technology development projects run under their mandate. According to Mahaney and Lederer (2003), exaggerated reporting is a source of information asymmetry in agency relationships. In this study, it was not possible to determine whether this information asymmetry is a deliberate "masking" of the TTO's actual performance by universities (Braun & Guston, 2003). However, this study was aiming to identify the actual or potential existence of information asymmetry than the motive. At the same time, it was not confirmed if MoST/MoSHE officials recognize the missing information in this reporting system or are aware of the status of technology development projects. This necessitates additional examination. The TTOs officials assert they merge reports of similar activities under their office since detailed reports will be cumbersome for recipients at the ministry, and it is customary to merge activity reports.

Details in reports are critical for research and a practical and informed decision-making purpose at a national level. For example, empirical research conducted in Sweden (Schnurbus & Edvardsson, 2020) and Germany (Berghaeuser & Hoelscher, 2020) found that TTOs in higher education institutions place a higher priority on the economic side of technology transfer than universities' social contribution of the third mission. This discovery is instructive for decision-making since it enables the gap to be addressed. To be more precise, the third mission's technology transfer objective is commercialization (Hellström et al., 2013; Kireyeva et al., 2020), whereas community service has a social responsibility component (Berghaeuser & Hoelscher, 2020). Combining the two project reports may not demonstrate that Ethiopia's two S&T universities are falling behind in the commercial objective of the third mission, or technology development and transfer in this case. However, this is a potential information asymmetry and needs further investigation by involving officials from MoST/MoSHE.

In sum, information asymmetry was found in the process of project selection owing to the knowledge and skill gaps of peer evaluators in charge. TTOs also have information asymmetry on technology developers' budget spending and activities during the technology development process. This compelled TTOs to take curbing decisions on the amount of time and budget allocated to projects during project selection. Given the limitations in this study, TTOs reporting content also manifests missing detail information to ministries shows potential for information asymmetry. These information asymmetry cases have an impact on the outcome and result in agency problems of technology development and should be addressed.

5.3.Agency problems

The data analysis and results discussed the unique characteristics of actors, their relationship, and the dynamics of the goals of principals and agents, and information asymmetry. In an agency relationship, goal conflict and information asymmetry are the sources of the agency problem, namely moral hazard and adverse selection (Bergen et al., 1992; Eisenhardt, 1989). The following section discusses the identified and potential agency problems identified at the two S&T universities examined in this study.

5.3.1. Adverse selection

The effectiveness of technology development is contingent upon the academic staff's ability and knowledge, among others. The academic staff's quality is crucial to creating and transferring technology's output (Secundo et al., 2016; Friedman and Silberman, 2003; Jensen et al., 2003). However, one of the questions that can be raised is the choice of universities for technology development and transfer mission, which affects the success of the technology transfer program (Rasmussen & Gulbrandsen, 2012; Guston, 1996). This could be determined by the number of Ph.D. holders in the universities, as suggested by Friedman and Silberman (2003). These analysis options are crucial to research the academic staff profile and participation in technology development and transfer projects. However, this is beyond the scope of this study. Instead, the study revealed factors indicative of adverse selection of project initiatives.

One way to avoid adverse selection in an agency relationship is to get detailed information on the agent before signing the contract (Eisenhardt, 1989). This is to ascertain whether the agent processes the necessary skills and abilities to assume responsibility for the work in the relationship (Shapiro, 2005; Eisenhardt, 1989), in this context, technology developers. According to Gulbrandsen (2010), TTOs must possess technical and business skills to pick viable initiatives for technology development and commercialization success. However, the two science and technology universities' TTOs lack relevant technical staff to evaluate projects.

Theoretically, adverse selection occurs in an agency relationship due to information asymmetry during the agent selection process (Fleisher, 1991), or in this case, during the project review process. Distinctive technology development project features make it difficult to provide detailed information at an early stage of technology development (Agrawal, 2006 as cited in Gulbrandsen & Rasmussen, 2012; Johnson, 2011). Performance of technology developers is contingent upon their commitment to technology projects (Rasmussen & Gulbrandsen, 2012). However, Fleisher (1991) contends that an agent's dedication alone is insufficient to ensure task performance without the requisite skills and talents derived from selecting the appropriate agent.

Accordingly, some technology developers reported their “knowledge and skill gap” concerning their project, which they realized during the implementation of the projects. Such experiences imply that technology developers failed to know and include the "correct" technical information in their project proposal. This was not identified by peer evaluators during project evaluation either, implying the possibility of an adverse selection (Bergen et al., 1992). Moreover, the lack of commitment from some peer evaluators, according to TTOs’ officials, and technology developers implies adverse selection of peer evaluators.

Additionally, TTOs officials indicated that some technology developers delay projects “on purpose” by invoking outcome uncertainties. This also indicates adverse selection based not only on the knowledge and skill of technology developers but also a possibility of adverse selection on their characteristics (Bergen et al., 1992) or dedication (Rasmussen & Gulbrandsen, 2012).

Thus, there are two ways to reduce adverse selection caused by information asymmetry. The first is to gather information; the second is to enter outcome-based contracts with the agent (Eisenhardt, 1989; Eisenhardt, 1985). Currently, the two institutions use outcome-based contracts. Nevertheless, addressing the technical knowledge and skill gap of technology developers and peer evaluators is vital for practical purposes. Therefore, the solution is explained in the concluding chapter of this paper.

5.3.1. Moral hazard

The principal-agent goal conflict is the primary source of moral hazard. A moral hazard occurs when an agent acts contrary to the agent's agreed upon agreement (Kivistö, 2005). The primary reason for this break from “agreement” is a disagreement about goals or priorities (Rasmussen & Gulbrandsen, 2012; Bergen et al., 1992; Eisenhardt, 1989). The two S&T universities' goals on the technology development program are defined in their written mission statements and TTOs’ manuals. Similarly, the goal of MoST/MoSHE also stems from the written mission of the universities, which were developed with the involvement of the supervising ministry. The shared goal is for universities to develop and transfer technology outputs to the industry development as means to bring socio-economic development. Meanwhile, MoST/MoSHE evaluates the attainment of this goal through measurable number of projects.

Nonetheless, given the projects' delays, interruptions, and a high degree of uncertainty over their outcomes, TTO officials specifically expressed that they would seek technology development projects that can be managed by the time and resources they consume. At AASTU, this direction was taken practically by rejecting at least one “complicated” project that met the university's thematic area of technology development and aligned with the TTO's aims. This will deviate from the priority set in the technology development and transfer mission, which amounts to moral hazard (Bergen et al., 1992). In this context, there is neither time nor financial resource “constraints" in terms of shortage, but the new approach of project selection will limit the number and scope of future projects that could serve end-users’, the industries and societies’, need. This conclusion is mainly based on the future course of action contemplated by TTOs than a prevalent practice so far.

Information asymmetry could hide moral hazards in an agency relationship. Accordingly, an agent may exploit the information advantage he or she possesses over the principal to act against the principal's best interests (Braun & Guston, 2003; Ferris & Graddy, 1998). As a practice in ASTU and AASTU, TTOs do not use technical monitoring mechanisms during project development, hence missing the cause of project delays. The technology developers argue that project delay results from outcome uncertainty factors related to finance and procurement. Meanwhile, TTOs claim that some technology developers “intentionally” delay projects. Petersen (1993) argues that moral hazard from hidden action, because the principal dose not observe the process, is minimized by monitoring tasks in progress. However, TTOs could not verify this, as technology developers blame uncertainty factors, and the technical development tasks and processes are not monitored. Hence, it is not possible to conclusively assert that technology developers purposely delay projects or engage in shirking (Kivistö (2005).

The budget utilization process is the other potential area for engaging in moral hazard. Technology developers receive direct access to the per diem budget to cover costs of travel related to the project. TTOs and the financial directorate officials claimed that this budget item was used as an incentive by technology developers. Additionally, some technology developers stated "per diem" as their sole financial benefit, which is not the intended purpose of per diem in the budget breakdown, confirming moral hazard.

TTOs’ officials also believe that technology developers exaggerate the project's duration in the proposal to maximize their gain from the three-credit hour per week allotted for the project engagement. This is consistent with moral hazard, in which an agent prioritizes private interests over those of the principal (Kivistö, 2005). As a result, TTOs’ officials make a concerted effort during the project selection phase to limit both per diem and project duration. On the other hand, a flaw in decision-making process of limiting the budget and project duration by TTOs could contribute to impairing the projects' outcome. This occurs if project developers, as they asserted, have been correct in their per diem and project life proposal.

Moral hazard is minimized by monitoring tasks in progress (Petersen, 1993). However, there is no mechanism to monitor the money spent on travel and accommodation. This is because there is no mechanism to oversee travels by TTOs. Petersen (1993) labels this as hidden action whereby information asymmetry is created when the principal is not able to oversee the activity. Similarly, because there is no technical oversight of projects and technology developers’ activities and outcome uncertainties are pervasive, there is no established system for controlling the time required and spent on projects. This supports Eldred and McGrath's (1997) argument that predicting the time required for technology development initiatives is more complex than for other types of projects.

5.4. Outcome uncertainties

The presence of separate entities (i.e., Most/MoSHE and MoF) in charge of supervising conflicting goals of technology development objectives and adhering to financial and procurement rules and regulations created outcome uncertainties. Because outcome uncertainties are beyond the principal's and agents' control, they decouple an agent's effort from the outcome (Petersen, 1993; Bergen et al., 1992; McGuire, 1988). The ASTU and AASTU technology development processes are characterized by such outcome uncertainties.

MoST/MoSHE and TTOs, as principals, and technology developers, as agents, have no control over the rules and regulations governing financial expenditure; MoF does. The finance and procurement directorates safeguard MoF's objectives within the universities. As a result, finance and procurement rules and regulations prevent project developers from obtaining high-quality materials on time, which directly affects the quality and on-time completion of the technology output. The MoF and its agencies promulgate financial and procurement laws and regulations for all federally funded public institutions, including public higher education institutions, without regard to the unique characteristics of each university-based program. This practice was older than the introduction of the new mission of technology development in the two S&T universities. The outcome uncertainties resulted in a similar finding with Göransson et al. (2009) that an old legal system impeded a new technology transfer system in Russian universities.

Even if technology developers successfully launch projects, they will encounter skill and knowledge gaps during the technology development process, adversely affecting the output. At the same time, the dynamics developers encounter during the technology development requires flexibility to change the material and financial plan. However, the line-item budgeting and expenditure control stands in the way of the inherent need for flexibility of technology development. This influences the enforcement of outcome contracts at the two S&T universities. This challenge is also asserted by Ouchi (1979) stating rules and regulations are not compatible with innovative undertakings in academic institutions.

Some of the approaches used to mitigate the outcome uncertainty factors have elements of practices used in clan socialization from control theory. For instance, using a social network to mitigate uncertainties in the procurement process and utilize laboratories inside and outside universities indicate features of clan socialization, mainly self-control and taking responsibility

(Shapiro, 2005; Abernethy & Stoelwinder, 1995). The support system (Abernethy & Stoelwinder, 1995) that top management renders during challenges by communicating with MoF (for example see appendix 4) is an example of clan socialization.

5.5. The contract types, outcome measurability, and task programmability

Outcome-based contract and measurability

The outcome-based reporting system has been used between MoST/MoSHE and TTOs/universities[37] and between the TTOs and technology developers. MoST/MoSHE is responsible for overseeing university-based projects that have been "completed" or "transferred." The process begins with annual plan broken down into quarterly plan submitted to MoST/MoSHE first at the beginning of the year. Subsequently, every quarter performance is reported by comparing it with the plan quantitatively, making the outcome measurable. In an agency relationship, the measurability of outcome depends on the principal's ability to measure and observe it (Mahaney & Lederer, 2003; Kivistö, 2005b). However, there is no information indicating the ministry officials check the actual completed and transferred projects reported. Moreover, because the ministry's job is to oversee all public universities and the operation of universities (including academic programs, research, and technology transfer and administration), the ministry may overlook details of reports in technology development. Braun and Guston (2003) also argue that ministries at a national level may not have the expertise and other resources to precisely control universities' activities.

The content of reports to the ministries and the contract between TTOs and technology developers demonstrate that the principals at both levels are interested in the output of the technologies developed. The most suited contract should mitigate goal conflict and information asymmetry (Eisenhardt, 1989), outcome measurability, task programmability, and outcome uncertainty (Kivistö, 2005). The outcome-based contract and control depend on the measurability of the task's output (Ferris & Graddy, 1998) and its effectiveness depends on the principal's ability to discern and measure the output (Mahaney & Lederer, 2003; Kivistö, 2005b).

In ASTU and AASTU, technology developers define the parameters for determining technology development project outcomes. Technology developers assert that defining "measurable"

[37] This is to imply despite the hierarchical relationship between the universities and the ministry, TTOs represent the universities in the technology development mandate

outcome targets was possible in their project proposals. Yet, the appropriateness or relevance and completeness of the targets were not tested and measured, because of outcome uncertainty factors. This is critical as Kivistö (2005) stated, finding the correct entity to measure outcome, and setting the right measurement approach is vital in an agency relationship.

Even if the contract is outcome-driven in the two S&T universities, achieving it has been proven difficult. Hence, the assessors have relied on the "functionality" of the technologies developed to "measure" the outcome. In general, these findings again corroborate Kivistö's (2005) argument that it is difficult to identify the appropriate outcome measurement and tasks in institutes of higher education where activities are unique and non-repetitive. For instance, completing projects according to the schedule approved in the contract is an output measurement. However, the uncertainty factors influence the completion time of the project. Currently, the outcome uncertainties significantly impact project outcomes which have reduced the effectiveness of enforcing outcome-based contracts. This confirms the idea that the inherent unpredictability of technology development (Rasmussen & Gulbrandsen, 2012; Eldred & McGrath, 1997) makes outcome-based contracts challenging to implement. Kivistö (2005) argues that using an outcome-based contract when outcome uncertainty is prevalent is disadvantageous for an agent.

Owing to the outcome uncertainty challenge, peer evaluators of technology development outputs overlook measuring the targets set in the proposals and use subjective criteria to evaluate projects. However, the data gathered indicate that the technology developers and evaluators disagree if the subjective evaluation goes against the former. Failure in measuring the outcome itself suggests the readiness for transfer is minimal at best. This is because the quality of the output is a requisite to transfer and commercialize technologies developed (Secundo et al., 2016).

Behavior-based control and task programmability

When outcome measurability is complex, the alternative contract type is a behavior-based contract. In this scenario, behavior-based contract and control needs task programmability and observation (Lasser & Kerr, 1996; Eisenhardt, 1989), a detailed procedure of tasks (Schillemans & Bjurstrm, 2020; Fleisher, 1991), among others. However, in the two S&T universities, behavior-based contract and control are challenging to employ even if tried. This is because technology developers could not outline details of tasks at the proposal stage due to knowledge and skill gaps. Each project has its own distinct set of tasks, which developers become increasingly aware of as they work on the project. Meanwhile, the behavior-based contract requires predetermined (York &Ahn, 2012) observable behavior and actions of the agents (Eisenhardt, 1989) which is task programmability (Johnson, 2011).

On the other hand, the MoF controls the way universities use their funds through procedures and layers of authority. As a result, the ministry employs the monitoring instruments outlined by Kivistö (2005) regular reporting using line-item budgeting, layers of control system involving auditor general and procurement agency. This control method is incorporated in the university's internal system. Technology developers plan their budget in a line-item budgeting system, and TTOs and finance directorates serve as layers of a control management system. The detailed procedure, reporting system, and line-item budgeting refer to behavior-based contracts (Johnson, 2011; Kivistö, 2005).

TTO/ finance directorate enforces behavior-based contracts to manage funds and contribute to the outcome uncertainty of projects. This affirms the results that universities operate within procedural limitations, including "rules and guidelines" in the context of a government-university relationship (Schillemans & Bjurstrm, 2020, p.9). This appears to have resulted in what Kivistö (2005) dubbed the accountability conundrum, in which the TTOs prioritized financial procedures over accountability for technology development outcomes.

In sum, the existing application of outcome-based contracts for technology development project outputs and behavior-based contracts for budget utilization opened a door for uncertainties into the projects' outcomes. Thus far, outcome uncertainties, knowledge and skill gaps among technology developers have affected the projects' outcomes. As a result, projects were delayed, and the quality of outputs was adversely affected.

Chapter 6: Conclusion

The primary objective of this research was to address three questions about the practice of technology development in Ethiopian science and technology universities since 2015. The study used agency theory as a lens and control theory to complement it. The first question sought to identify the actors involved in the process of technology development and to explore the aspects of their relationships. The second inquiry was about how the actors' relationships, as identified in the first question, affect the outcome of a university-based technology development program. Finally, the third inquiry was raised to advance solutions based on the gaps highlighted in the actors' relationships and their impact on the outcome of technology development. This section concludes with the finding answering the three questions; give meaning through previous research works and forwarding future research agenda.

6.1.Technology development actors and relationships

6.1.1 Actors in the technology development process

The actors of technology development refer to institutions and units within institutions in which individuals and groups are involved in the technology development process of the two S&T universities. The actors identified as principals and agents are mentioned as units, including TTOs, finance and procurement directorates, and MoST/MoSHE. The role and decision-making of these institutions and units are explained by individual's actions within units, as Kivistö (2007a) asserts. Mason et al. (2006) used the same approach of using groups as principals and individuals as agents to conduct an empirical study using agency theory. The grand assumption of this is "methodological individualism," whereby a social and economic phenomenon is explained by individuals' "conscious action" (Donaldson, 1990, p.371).

The primary goal of identifying actors in the technology development of the two S&T universities is to identify their agency relationships. The agency connection exists when one party hires, represents, or is engaged by the principal to make a specific decision (McGuire, 1988; Ross, 1973), and the principal relies on the agent's action (Pratt & Zeckhauser, 1986). The basis or premise for such relationships is either the agent's unique skill (Shapiro, 2005) or the agent's lower-cost advantage in performing the work (Fleisher, 1991). The decision-making power given to agents is *technology development* in the two S&T universities' case study context. As a result, the agency relationship between actors is established based on the actors' interactions in the technology development process decisions at the two S & T universities.

MoST/MoSHE and universities

The two S&T institutions' mission of technology development and transfer is a component of national policy (FDRE, 2010; MoFED, 2010). Thus, structural (i.e., reporting and funding) and legal links were established from the national level down to institutions. This created legal and resource accountability to the government, as explained by Marhl and Pausits (2013). As such, the two universities in Ethiopia were established and restructured by proclamation following a proposal by the Council of Ministers and approval of the national parliament (see FDRE, 2014). The proclamations place the two S&T universities since 2015 under the supervision of two ministries, first under the mandate of the Ministry of Science and Technology (MoST) and then under the mandate of the Ministry of Higher Education (MoSHE) in 2018. Because universities are answerable to the ministry (i.e MoST/MoSHE), the legal framework establishes MoST/MoSHE[38] as the principal for the whole operations of the universities. This in turn made universities agents of the ministry. However, the critical element to note in this case study is that the agency relationships identified are based on the technology development process and decision-making. As such, the two universities report to the ministry regularly, including their technology development and transfer. Van Slyke (2007) asserted that performance reports are markers of agency relationships in public organizations, strengthening the principal position agency relationship between MoST/MoSHE and the universities. However, the universities' agency relationship adds another principal, MoF.

MoF and Universities

The government is the sole funding provider for technology development and transfer programs, and the MoF administers the budget channeling and control at a national level. The resource and budget allocation and control process also signifies agency relationships (Van Slyke, 2007). The MoF incorporates national-level agents (i.e., auditor general and procurement agency) to supervise financial resource utilization and regulate procurement procedures in all federal

[38] Ministry represents MoST and MoSHE in the respective time of their mandate supervising the universities, hence MoST/MoSHE is used

institutions, including universities. As a result, MoF serves as a principle for universities as a source of budget, and the relationship involves a reporting and auditing control mechanism, indicating an agency relationship (Schillemans & Bjurstrm, 2020; Johnson,2011). The MoF has a direct working relationship through an item-based budgeting approach and periodic reporting with universities' finance directors. The auditor general audits universities' financial management and the procurement agency establish detailed rules, regulations, and procedures governing universities' procurement activity and audits the process. The details of the agency relationship between MoF and finance and procurement directorates are beyond the scope of this study. Meanwhile, within universities, the relationship between the universities and the ministries (MoST/MoSHE & MoF) is reflected in a particular arrangement.

The universities are structured based on programs which are academic, administration, research, and technology transfer, among others. Activity performance reporting to the ministries and budget allocation and control are carried out along these program lines. Thus, each university's TTO is autonomous in making decisions throughout the technology development process and reporting its technology development and transfer performance. This is critical to answering which unit represents the university as an agent for technology development. TTOs report is sent to the supervising ministry, MoST/MoSHE, via the vice president for research and technology transfer.

The role of TTOs as agents or principals depends on the context as identified by Gulbrandsen and Rasmussen (2012) and Rasmussen (2012) with national funding entity and university management. In the hierarchical relationship, the top university management is accountable for the supervisory ministry. Owing to the scope of this study, there was no control identified from the top management on TTOs' during the technology development process or any changes top management makes on the report of TTOs to the ministry. Instead, the TTOs' report directly reaches MoSHE/MoST, making TTO an agent responsible for overseeing the technology development. However, this does not exclude the agency relationship between top management and TTOs, such as in administrative areas. The position of TTOs as an agent is in line with McGuire (1988) and Ross (1973); asserting agency relationship exists for a particular task and decision-making process.

TTOs and technology developers

TTOs make a call for a project proposal for academic staff to develop technologies. This agency relationship is based on the unique skill, a rationale for agency relationship (Shapiro, 2005), of academic staff to carry out the technology development activity. The academic staffs submit proposals and work on technology development projects. Thus, academic staff technology developers act as agents for TTOs in developing technology, while TTOs act as principals, with overseeing power through a formal contractual agreement, a means of agency relationship management (Kivistö & Zalyevska, 2016; Mahaney & Lederer, 2003; Fama & Jensen, 1983). Meanwhile, additional actors are involved throughout the process, from the technology development project selection to the completion of the project.

TTOs and Peer evaluators

TTOs utilize a peer-review approach for project screening and evaluation based on the idea that academic staff peers possess the educational background necessary for screening feasible projects. As such, the peer evaluators work on behalf of TTOs in screening projects and evaluating the outcome, implying an agency relationship (Eisenhardt, 1989). Nonetheless, the TTOs do not have control over peer evaluators, which is another requisite in an agency relationship (Braun, 1993), with implications on the relationship. This is a relationship feature that distinguishes actors involved in technology development at the two S&T universities.

Procurement and finance directorate and TTOs

Peer evaluators conduct technical evaluations of project proposals during the project selection phase of technology development. TTOs' officials evaluate the budget proposal of projects. The financial appraisal of the project is contingent upon the budget plan submitted by the technology developers, which is generated using line-item budgeting. TTOs' and finance directorates' work in tandem to ensure that financial rules are adhered to by technology developers.

Similarly, the TTOs verify the budget and items to be procured request by developers conform to the proposal's budget breakdown. TTOs, finance directorate, and procurement directorate ensure the rules and regulations of MoF, and its agencies are not violated. Moreover, TTOs get into a contract with technology developers about the financial utilization rules and regulations and consequences in case of violation which is the interest of the finance directorates. As their actions are consistent, both TTOs and the finance directorate act as what Kivistö (2007a) refers to as group-level "principals" in monitoring budget utilization of technology developers.

On the other hand, the technology developers send their procurement requests to the procurement directorate after TTOs' approval if the items are on the budget proposal. The directorate buys the materials on behalf of the technology developers indicating a dependency relationship, which in turn indicates an agency relationship (Pratt & Zeckhauser, 1986). However, neither TTOs nor technology developers control the directorate; hence, the agency relationship is not "complete," with an implication on the outcome of projects.

Features of actors' relationship

The features of the relationship represent actors' unique relationships among actors with an implication on the outcome. At the national level, MoST/MoSHE oversees the universities based on a quantitative reporting system, comparing the number of technologies planned and developed and the number of technologies transferred from the two universities. Outcome-based control is preceded by specifying the "targets" and the expected outcome results (Snell, 1992, p. 296). Thus, the relationship between MoST/MoSHE and the S&T universities can be dubbed as an outcome-based "contract" whereby the universities submit their annual plan on the targets at the beginning of the year and report the performance against it periodically. However, the reporting overlooks details showing the technologies developed and transferred since TTOs' officials merge them with other project activities' report they oversee. This inflates the technologies "developed" and "transferred." Despite the lack of information from the MoST/MoSHE officials in this study, this implies the potential information asymmetry on the actual performance of technology development. Moreover, since the ministry is accountable for controlling the programs and activities of all public institutions, the existence of information asymmetry is plausible.

Meanwhile, MoF and its agents control the universities, mainly the finance and procurement directorate, based on regular reporting and line-item budgeting, a behavior-based control approach (Schillemans & Bjurstrm, 2019; Kivistö, 2005 as cited in Kivistö & Zalye, 2015). MoF ensures a thorough procurement procedure through the procurement agency. This is ensured with in universities by introducing rules and regulations and the regular report and audit of finance and procurement directorates of the two universities. However, the rules and regulations created outcome uncertainties on the technology development projects, which is a critical finding on these actors' impact on technology development outcome.

The TTOs and finance directorate are joint principals in ensuring financial rules and regulations by the technology developers. The procurement directorate does not have an agency relationship based on a control role with technology developers or TTOs. Nevertheless, the procurement directorate carries out procurement for technology developers, and the relationship affects the outcome of projects.

TTOs and technology developers have an outcome-based contract for timely completion of projects and output delivery according to targets on the project proposal, which is part of the contract. Technology developers themselves set the output target. Meanwhile, the contract agreement between TTOs and technology developers also outlines a behavior-based contract on financial expenditure. These contract articles ensure adherence to MoF and its associated agency rules and regulations, overseen by universities' finance directorates.

Finally, the peer evaluators also work on behalf of TTOs to select projects. Their role is vital in selecting feasible projects and improving project contents. However, lack of commitment by some evaluators implies adverse selection of the same. The evaluators are chosen based on their education background closeness to the project from within universities. The lack of knowledge about the specifics of technologies they evaluate indicates information asymmetry, and adverse selection of technology projects. This entails the new approach to get technology project evaluators.

6.1. Actors’ relationships and technology development outcomes

This section answers the research's second issue: determining the effect of actors' relationships on the outcome of technology development. The links are explained in terms of the national and university-level actors in the technology development process.

Supervising ministries (MoST/MoSHE and MoF) and technology development

MoST/MoSHE monitors the activities of universities through a reporting system. TTOs report the number of completed and transferred projects to MoST/MoSHE as their activity performance. However, the relationship has not demonstrated how the supervisory ministry oversees the completed and transferred technology outputs to check the reality of the report.

Additionally, because MoSHE governs all higher education institutions and their programs, closer oversight and attention to detail are difficult to achieve, as performance is communicated through written self-reporting by TTOs/universities. For instance, universities' current reporting system mixes technology development and transfer performance reports with community service in ASTU and student technology development projects in AASTU. Such a reporting relationship potentially results in information asymmetry by hiding the details of technology development and transfer meant for commercialization. This is critical since a high-quality performance-reporting system is one of the indicators of an agency relationship (Van Slyke, 2007), which is a gap in this case.

Within the universities, TTOs in the S&T universities report the outcome of technology development. The outcome-based contract is optimal for harmonizing the principal's and agents' objectives (Van Slyke, 2007; Bergen et al., 1992), as expressed in the mission statements of the two universities in this case. As stated before, TTOs report to the supervising ministry the number of projects completed and transferred. Because of outcome uncertainty factors, attaining project completion has been a challenge. As a result, TTOs are drifting to prioritizing "easily" doable projects, which will stray from the shared goal and creates a potential moral hazard as an agency problem. While such measures may improve project completion rates and timeliness, they fall short of contributing to socio-economic development through technology transfer, as stated in universities' mission statements. MoST/MoSHE does not monitor such deviations since the task monitoring mechanism is unavailable under the existing reporting system.

The reporting relationship between MoST/MoSHE and the TTOs/universities corresponds to Caswill's (1998) argument that national ministries are distant in their working relationships with universities resulting in information asymmetry. Meanwhile, more research on the information that may be gleaned from ministry officials can assist in moving beyond predicting the potential impact to determining the influence of the reporting system on information asymmetry and their shared goal.

The relationship between the MoF, including its national level agents for auditing and procurement, and the S & T universities are centered on resource mobilization. The MoF does not control the budget amount spent on programs so long as it is under the budget ceiling for the allotted budget category or items, but it controls how it is spent. For instance, the assumption that universities seek maximize their funding from the government (Kivistö & Zalyevska 2016; Gulbrandsen & Rasmussen, 2012) was seen when the two universities applied to the Council of Ministers for a "massive" budget boost in 2014/15. However, it has not been fully utilized and there is no principal to oversee the largely underutilized budget (see appendix 1). MoST/MoSHE does not supervise the budget utilization performance. Addressing financial and procurement-related regulations in the technology development process is also beyond the reach of MoST/MoSHE. The impact of the relationship between the MoF and universities is reflected in the role of actors (i.e., finance and procurement directorates) who represent the MoF's "interest" in universities versus the outcome of university-based technology development.

Actors within universities and technology development

TTOs select projects using peer assessors to evaluate and improve project proposals. However, it was revealed that the peer assessors' lack of technical expertise to contribute to project improvement implies the possibility of adverse selection of projects. Technology developers' lack of skill and knowledge resulted in delays and missing output targets to technology developers, implying adverse selection occurred during project selection by peer evaluators due to information asymmetry in technical know-how.

Additionally, the dedication of peer evaluators has been questioned by TTO officials and technology developers, potentially contributing to adverse selection, which could also be a moral hazard in an agency relationship. However, TTOs and peer evaluators lack a "full-fledged" agency relationship of accountability to monitor their commitment.

As actors in technology development, finance, and procurement directorates affect project outcomes by creating outcome uncertainties. The uncertainty factors originate from the finance and procurement directorates adhering to the MoF's and its agents' rules and regulations. Hence, the outcome uncertainties are making outcome measurement and enforcing the outcome-based contract less practical at best. With outcome uncertainties, outcome-based contracts are unjust to agents (Kivistö, 2005), as the outcome may be unsuccessful despite the agent's efforts (Eisenhardt, 1989). Hence, completing projects on time and at the specified output target has proven challenging, for developers. Quality problems on technology output imply that technology's actual transfer and commercialization potential is questionable (Heslop et al., 2001). Meanwhile, failing to enforce the contract demonstrates that the primary shared goal of technology development and transfer for economic and social development is undermined. By extension, the mission, which was part of national policy initiative, was not enforced effectively. Since, the agent should stand for the principal's best interest (Bergen et al., 1992; McGuire, 1988), it is vital to bridge this gap in the current agency relationship.

The TTOs and technology developers have an outcome-based contract relationship, meaning that projects must be completed within the time frame and target set in the proposal. TTO officials assert that project delays are not exclusively due to outcome uncertainties but also due to technology developers' lax effort, which amounts to shirking. Moreover, lack of knowledge and skill of technology developers is an addition to the cause of missing project targets. This gap in knowledge and skill also impedes them from clearly setting all the tasks during the proposal development, even if the most of the technologies are copying existing ones. Employing behavior-based contracts is challenging since task programmability is not practical with developers' current skill and knowledge gaps to accurately layout the tasks at the planning stage.

Summary of the impact of actors' relationship on technology development outcome

The primary finding in technology development at the two S & T universities is the two supervisory principals (i.e., MoST/MoSHE and MoF) at the national level, which extends to internal actors' relationships. This has a range of implications for the agency relationship, including priority setting and monitoring challenges (Mason et al., 2006; Shapiro, 2005). When applicable, the TTOs at the two S & T universities prioritize compliance with the contract's financial rules and regulations over technology development operations. Such agency relationship creates an "accountability paradox" in which compliance with rules, laws, and procedures takes precedence over the outcome (Kivistö, 2005, p.9). In general, the requirement for outcome-based control was not effectively implemented due to issues with outcome uncertainties impairing outcome measurability. As a result, the output target of the technologies developed are adversely affected, which affects the readiness of technologies developed for transfer (Heslop et al., 2001)

Moreover, the existence of two principals, MoF and MoST/MoSHE separates the latter from mobilizing resources, limiting it to the authority of overseeing technology development through reporting. In an agency relationship, a principal mobilizes resources to protect its interests (Braun & Guston, 2003). However, MoST/MoSHE does not control the financial rules and regulations for incentives and fixing finance and procurement-related uncertainties in the technology development process. Meanwhile, the objective of MoF is designed to take control of how the budget is spent, overlooking the program effectiveness itself. Internally, lack of know-how about projects and lack of commitment resulted in adverse selection of project. The same challenge with skill and knowledge of developers contributed for missing outcome targets.

6.2. Mitigating the gaps in actors' relationship and outcome

This part addresses the third research question of advancing solutions based on the actors' relationships gaps identified and their impact on technology development at the two S&T universities. The solutions' primary objective is to uphold the technology development mission of the two S&T universities, as it is essential to adhere to the principal's priority in an agency relationship (Bergen et al., 1992; McGuire, 1988). The solutions are divided into establishing an intermediary entity and introducing clan socialization control during the technology development process to manage outcome uncertainties and nurture support system.

6.2.1. Establishing an intermediary agency

National level intermediary entity

With current system the separate principals overseeing the activity and resource allocation for technology development created outcome uncertainties in the technology development process at the two S&T universities. Eldred and McGrath (1997) contend that "too much structure" in the technology development process stifles innovation (p.44). As a result, the complex agency interaction between actors characterized by outcome uncertainties should be addressed in the technology development process.

Hence, at the national level, the oversight of universities' technology development efforts and financial resource management should be consolidated under a single institution. This can be accomplished by establishing an intermediary entity. Braun and Guston (2003) argued that an intermediary[39] agency staffed by technically competent persons can oversee, but not limited to, technology development programs more efficiently than ministries, which are distant in control relationships. Additionally, a government funding structure determines the attainment of

[39] The term intermediary refers to an entity between TTOs/universities and government which could be Council of Ministers in this case

university objectives (Braun & Guston, 2003; Braun, 1993). Thus, the new entity should be empowered to provide appropriate resources to an agent, TTOs, to attain the technology development outcome. As a result, the intermediary agency will be responsible for overseeing technology development and budget utilization, which was previously the separate responsibility of MoST/MoSHE and MoF respectively.

This solution is supported by a theoretical foundation, a favorable scenario for implementation, and a gap to overcome. According to an agency relationship theory, the principal's decision-making mandate about resource allocation to the agent motivates the agent to act in the principal's best interest (Braun & Guston, 2003). As a result, the principal's resource is necessary for an agency relationship to be effective (Rasmussen & Gulbrandsen, 2012; Braun, 1993). However, since MoST/MoSHE does not mobilize the resource, TTOs within universities have been prioritizing the interests of MoF. TTOs' resource mobilization for technology developers is governed by MoF rules and regulations which are not tailored to the technology development program's needs. As such, outcome uncertainties were generated for the program's primary objective of technology development. These findings corroborate Braun and Guston's (2003) statement that the principal should be able to allot resources for its agent for an agency relationship to attain the former's goals.

The core objective of establishing an intermediary agency is to ensure that technology development outcomes take precedence over financial and procurement rules and regulations. By tailoring budget utilization rules and regulations to the end goal of technology development, the uncertainties associated with finance and procurement rules and regulations will be mitigated. Outcome uncertainties occur when the principals and agents are unable to control the factors that influence the outcome (McGuire, 1988; Bergenet al, 1992; Petersen, 1993). As such, this solution will place the finance related rules and regulations made by MoF and its national agents, independent of MoST/MoSHE, under the decision-making authority of the new intermediary entity. As a result, the intermediary entity should customize finance and procurement laws and regulations to technology development initiatives. For instance, reimbursement could be permitted for materials obtained by technology developers from overseas using their social connections with expatriates (see outcome uncertainty factors section). Covering unexpected costs could be possible, as the inability to do so is an uncertainty factor. The outcome uncertainty factors hampered the evaluation of technology development outputs, their quality and progress, and impeded the execution of outcome-based contracts. If the new entity executed easing and tailoring the budget and procurement rules and regulations for technology development process effectively, outcome uncertainty in finance and procurement process will be effectively addressed.

Additionally, the new entity will maximize budget utilization for broader and diverse technology development initiatives to address the current underutilized budget portion of the total authorized budget (see appendix 1). Meanwhile, if the disconnect in the existing system was on the decision-making between technology development and budget utilization control alone, it might be bridged by combining the two decision mandates under MoSHE[40]. However, the gap of having two principals at the national level goes beyond operation and resource oversight mandate separation. The gap includes information asymmetry in reporting system to the ministry and TTOs deviating from the shared goals. The intermediary entity should address these agency problems in its relationship with TTOs, the agents. This solution will change the relationship between the intermediary entity and TTOs.

Intermediary entity and TTOs

In this study a potential of information asymmetry in the content of reporting system from TTOs to MoST/MoSHE and a diversion, from the shared goal of technology development was identified. Both problems could lead to a moral hazard by "hiding" information from the supervisory ministry. The agency relationship between the new intermediary agency and TTOs should address these problems. The exposure to this agency problem is magnified by the inability of MoSHE to closely oversee TTOs, since it oversees all public universities and programs under them. This is consistent with the finding of Braun and Guston (2003), and the solution they suggested was to establish intermediary agency, based on an empirical study. Hence, the new intermediary entity should have closer professional expertise in technology development, which will minimize information asymmetry in oversight. For instance, this will enable checking if the outcome targets reported in paper are actually achieved through different observation mechanisms, which is not practiced so far. This is because outcome-based dose not only relay on measurability of outcome but principal's ability to do so (Lasser & Kerr, 1996;

[40] MoSHE is used in the solution section since the current supervisory entity is MoSHE

Eisenhardt, 1989). Meanwhile, the establishment of such an entity has a favorable condition in Ethiopia. Public universities have been introducing research, technology transfer and community service projects based on the website of public universities visited. Hence, the intermediary entity can oversee the funding of such programs and beyond in the two S&T universities through TTOs and other units. Moreover, such intermediary public entities are available in various countries (see Gulbrandsen and Rasmussen, 2012). However, the establishment of this entity should be based on further studies (see the Future research agendas section for a broader scope section).

Contract type intermediary entity and TTOs

The relationship between the new entity and the university will have an outcome-based contract. The goal of technology development indicated in the mission statements of the two S & T universities should remain unchanged. This is in line with the agency theory assumptions that the principal's goal is a priority in an agency relationship, and the agent's actions and contract type should be in the principal's best interests (Bergen et al., 1992; McGuire, 1988). Furthermore, financial accountability, the outcome of the budget utilized, in public institutions should not be disregarded (Marhl & Pausits, 2013; Van Slyke, 2007). As a result, outcome-based contract and control should be maintained between the new entity and TTOs/universities.

The output control in technology development can be a prototype (Johnson, 2011), as it is currently used and programs and software outputs in IT projects. The approach of "mass" production of the prototype technology for transfer and commercialization, on the other hand, necessitates an independent study. This is because the study involves external stakeholders and multiple approaches available for the commercialization of technology developed (Rogers et al., 2001). Moreover, technology readiness for transfer goes beyond the prototype or object itself but knowledge that will be transferred along with it (Sahel, 1981; 1982 as cited in Bozeman, 2000). The transfer aspect of technology incorporates applying the information in the technology or enabling technology users apply it (Rogers et al., 2001). Hence, at technology transfer stage, new study is required to redefine the component of the outcome to incorporate the usability by users. Additionally, since in the current practice technology developers use impact as outcome measurement indicator, it can be measured and reported after transferring technologies. Outcome-based contracts can be enabled if the intermediary entity effectively customizes finance and procurement laws and regulations, among others. Other enabling measures are discussed in the second solution section.

The financial and budget utilization contracts can be a mix of outcome-based and behavior-based contracts, with control applied accordingly. This is possible as contracts can be on a continuum of both types according to Eisenhardt (1989). The outcome-based contract should encourage the utilization of the allocated budget for more technology development and obtain the outcome target. Because of the potential moral hazard posed by technology developers regarding budget spending of per diem, behavior-based control may not be ruled out. However, further research is required to design the detail and the balance of contract types for budget utilization and spending (see Future research agendas section for details).

To summarize, the essential purpose of the intermediary agency is to prioritize technology development outcomes over financial and procurement norms and regulations. This will avoid the "accountability paradox" raised by Kivistö (2005, p.9) and identified in this case study. Additionally, the intermediary agency will be able to keep close supervision since it will have experts. The new entity can supervise a complete report on the third mission component separately, which are technology development, community service, and student technology development programs in the two S & T universities. This solution will also alter the actors' relationship arrangements within the institutions.

Intermediary agency and internal actors' relationship

The internal budget utilization control was governed by the rules and regulations of MoF and backed by the finance and procurement directorates' oversight. With this solution, since one national entity oversees the technology development mission and budget utilization, the same should extend in the universities' internal structure. TTOs within universities should be empowered to control both the financial resource utilization and technology development projects. This is to mitigate outcome uncertainties, which are caused by factors beyond the control a principal (McGuire, 1988; Bergenet al, 1992; Petersen, 1993), which are TTOs. Hence, the decision-making authority over finance and procurement, which was not controlled by TTOs, will be transferred to them in the new system.

As a result, TTOs should have financial and procurement experts as employees to help manage outcome uncertainties related to them. This will create a “complete” agency relationship between TTOs and finance and procurement experts working under them, giving the former control power over finance and procurement process. Hence, uncertainty factors raised by developers and TTOs including delays from the current procurement directorates, a potential moral hazard, will be closely addressed since TTOs will have the power to control them. Thus, finance and procurement experts will act as agents of TTOs. Hence, TTOs prioritize the outcome of technology development by managing outcome uncertainties. This modification will strengthen procurement personnel's accountability to TTOs.

The control power of TTOs should be supported by the intermediary entity, at national level, relaxing and customizing the financial rules and regulations and prioritize technology development outcome. Hence, the finance and procurement related outcome uncertainties will be addressed at national level. As a result, TTOs, as agents of the new entity, will focus on the main goal of technology development, which will address the moral hazard of shifting from the objective in the process of project selection.

Like the relationship between the new national entity and TTOs, the contract between TTOs and technology developers should be outcome based. The rationale is the same with the former, public fund utilization accountability (Marhl & Pausits, 2013; Van Slyke, 2007). In finance utilization a mix of behavior-based and outcome-based contract should be applied since technology developers manifested moral hazard in budget spending mainly on per diem. Moreover, in public institutions, accountability for output and finance cannot be abandoned since the funding source is the public (Waterman & Meier, 1998). However, for practical implementation, a balance of TTOs’ and intermediary entities’ oversight using various contract types on financial and procurement processes needs further study. The contract between TTOs and procurement and finance employees should be based on the technical support they render to technology developers. As hired employees based on salary and the need to speedup financial and procurement process, behavior-based contract can be used, owing to further study.

In general, the main goal of this solution of empowering the new national entity and TTOs with operation and financial oversight to mitigate uncertainty factors related to finance and procurement. Hence, establishing a new intermediary body and empowering TTOs in the resource control will yield the outcome essential for government-driven policy. As such, since the principals control resources, they can make their respective agents pursue their interests (Rasmussen & Gulbrandsen, 2012; Braun, 1993). Consequently, outcome-based contract between principals and agents (i.e the new entity and TTOs and TTOs and technology developers) on technology development process should be enabled. Prioritizing technology development outcome is the key in the process. Meanwhile, the contract on finance utilization and with finance and procurement employees should be subject to further study. However, this solution is not enough to address all the outcome uncertainties and gaps identified, leading to the second solution of applying clan socialization.

6.2.2. Applying clan socialization control

Gaps to be addressed by clan socialization and input control

Most of the technology development projects at the two S&T universities are copying and modifying existing technologies. As a result, technology developers were able to set quantitative project output targets. The primary impediment was the outcome uncertainties, which rendered outcome-based contracts unenforceable. Hence, establishing an intermediary agency addresses the finance and procurement rules and regulations related uncertainties.

Meanwhile, technical skill gaps of technology developers and uncertainties related to lack of stakeholders' cooperation were identified as a gap affecting the outcomes of technology development. Additionally, the selection of technology development projects is influenced by information asymmetry on the part of peer evaluators, resulting in a potential adverse selection of projects. This is because lack of competence to make project evaluation and lack of commitment during evaluation. Since there is no behavior-based contract and control, such gaps are not addressed in the existing system.

When behavior and outcome-based contracts are not practicable in an agency relationship, clan socialization and input selection are the ideal substitutes according to control theory (Eisenhardt, 1985). As such, the unpredictable nature of a task necessitates the use of input, social and self-control capacities, augmented by “training” and “socialization,” to foster the shared goal (Abernethy & Stoelwinder, 1995, p.3).

Clan socialization for capacity building of technology developers

From the data collected, the gaps in knowledge and skill to practically build technologies is the challenge facing technology developers. To bridge the knowledge and skill gap, intervention is needed. Unlike the market context where the availability of principals and agents is determined in a broader market environment (Kivistö ,2007a), the two S & T universities' TTOs use existing academic staff to further technology development goals. Quality and competence of academic staff are determinant for the success of technology development and viability for transfer (Friedman & Silberman, 2003; Jensen et al., 2003). One approach could be acquiring competent staff through hiring process, which depends on multiple factors (Houston et al., 2006) entailing further study. Meanwhile, the current knowledge and skill gap among technology developers can be addressed through capacity building and support system by introducing clan socialization in the process.

According to Ouchi (1979), workshops and seminars serve as a vehicle for clan socialization and the pursuit of common goals. This includes exposing technology developers to training, visits, and workshops with experts from industry and other universities and institutes, including institutions abroad while developing technology. This is consistent with the view that innovation and research-related activity is complex (Eisenhardt, 1989) and may not be well managed by rules and controls (Ouchi, 1979). This is critical for building the capability necessary to achieve the intended outcome of technology development and construct a support system within the dynamics of technology development progress. In the popular work of Heslop et al. (2001) technology readiness study, "support system" during the technology development process in higher education institutions is identified as a critical factor for the ultimate transfer of projects (p.373), which is also asserted by Secundo et al. (2016). Clan socialization builds support system by engaging stakeholders needed in this context.

This also backs the two S & T universities' technology developers' assertion that technology development requires learning and flexibility in their experience. Additionally, this will address the moral hazard associated with "intentional" project delays, as claimed by TTO officials, since clan socialization constantly establishes a common objective through support system (Ouchi, 1980). This is because clan socialization concept emphasizes the importance of "socialization" and "training" to break free from the previous system and develop a common goal (Abernethy &

Stoelwinder, 1995, p.13). Hence, TTOs will address the outcome uncertainties by helping developers acquire support from experts in their technical challenges through training, seminars, workshops, and network with stakeholders. As Ouchi (1980) suggests clan socialization improves systems through time. As it is consistently applied, it will result in mutual understanding and solving challenges and building common goal.

Self-control is also vital components of clan socialization. Mills (1983) argued that when outcome uncertainty is combined with information asymmetry, outcome and behavior requirements are hard to establish in advance which entails self-control. This is especially true when task programming is challenging (Snell, 1992; Eisenhardt, 1985), as with the two S & T universities’ technology development projects. According to Miller (1983), managers should assist employees through a "consultative" management style. This will reinforce the self-control that technology developers currently exercise. For instance, developers employed various strategies and initiatives to address outcome uncertainties throughout the technology development process. Utilizing personal networks to overcome barriers to accessing industry workshop facilities and professionals, for example, is critical when resource is constrained. Thus, the TTOs and the intermediary agency should facilitate such self-control-based initiatives through a flexible finance and procurement system and stakeholder engagement.

Integrating potential technology output users and external stakeholders in seminars, training sessions, and the selection and evaluation of projects will assist in establishing a unified objective. This will alleviate the outcome uncertainties created by the “lack” of cooperation from some technology developers' external stakeholders. Building relationship with industry and other stakeholders of technology development takes time, as clan socialization refines systems through time (Ouchi, 1980). Meanwhile, the involvement of potential stakeholders requires independent study from university-industry link perspective.

Why clan socialization?

Organizational control theory was added to complement an agency theory in this study. Accordingly, the clan socialization addresses the gap in managing an agency relationship when both task programmability and outcome measurability are not possible (Eisenhardt, 1985). However, in the two S&T universities’ technology development context, setting measurable outcome targets was possible so far. However, the task programmability and attaining the outcome targets has been difficult because of outcome uncertainties related to finance and procurement, skill gap and cooperation from external stakeholders.

By building a support system through clan socialization in the process of the technology development, the uncertainties will be addressed, enabling outcome measurability. This is on the top of making the finance and procurement decision making power under the new entity and TTOs. That is the reason why outcome-based contract should be the contract type to manage technology development in the two S&T universities. Meanwhile, outcome measurability will be possible if clan socialization is used during the technology development to address knowledge and skill gap and nurture stakeholder cooperation. Since each project is unique, the support system should continue to address the challenges of skill gap and “lack” of stakeholder cooperation uncertainties, which is critical for technology development success (Heslop et al., 2001). If the support system is withdrawn, the uncertainties will prevail again, since skill gaps in technology development among others will not be mitigated. As such, instead of behavior-based contract and control during carrying out the task of technology development, clan socialization approach will handle the gaps identified during the process.

Input-based control by attracting competent evaluators

The challenge of capable project evaluators is one of the gaps identified in this study. In complex systems of technology transfer, TTOs have their own specialized staffs with experts in both science and business to be effective in project selection and commercialization (Hülsbeck et al., 2013). Given the few projects the TTOs run currently, for example by comparing the budget consumed with the total budget allocated (see appendix 1), hiring permanent staff evaluators may not be viable option at this time. So far, using internal staff as peer evaluators failed to deliver the desired result, because of lack of knowledge and skill and commitment. Hence, TTOs should engage experts with experience in research and technology development and potential technology users from an industry to participate in the project evaluation and selection process. Such experts should be sourced from external industry and from institutions locally and abroad. This is by assuming the knowledge gap to evaluate projects is common among the existing staff, which needs further study.

The core element of this solution is to attract competent in experience, knowledge, and skill evaluators for project selection. The principals, the new entity and TTOs, as a party mobilizing resource (Braun & Guston, 2003), can acquire competent evaluators. This will enable selecting the best projects during project selection, which is an input control in control theory (Johnson, 2011) and selection of competent agents in agency theory (Eisenhardt, 1985). This is because qualified project evaluators will select projects and provide recommendations on how to improve them, which is already the expectation of TTOs' officials of the universities. The evaluators will not simply "accept" or "reject" the project proposal but actively contribute in its advancement.

TTOs should make their relationship with project evaluators contract-based to ensure responsibility and commitment. Hence, this creates an agency relationship, which is recommended based on the potential agency problem of lack of commitment, moral hazard, with the current peer evaluators. However, assuming the new external evaluators will manifest the same behavior with the peer evaluators so far has its limitation as a premise to establish agency relationship.

Competent project evaluators should assist in establishing the project's technology output targets. Setting measurable targets for technology development projects is feasible because most projects replicate or modify existing technologies, which competent and experienced evaluators can supplement. Abernethy and Stoelwinder (1995) assert that the clan socialization strategy for creating output targets for professionals operating in a bureaucratic environment needs an expert setting the output target. As a result, acquiring skilled project evaluators is critical for ensuring effective project selection and minimizing adverse project selection. This recommendation is forwarded because currently developers set their own measurable output targets and it has not been tested for reliability and completeness, because of outcome uncertainties. As Kivistö (2005) stated deciding how to measure the outcome of an agent's task and who will measure it is a critical decision in an agency relationship. The involvement of expert evaluators from industry and institutions will add not only to the measurability of outputs, but also to the completeness and relevance of what is measured as output. Moreover, involvement of potential technology users is crucial since the technology developments' objective is to transfer and commercialize. This will cement the quality of projects, by adding input for developers' proposal.

Meanwhile, the evaluators' incentive system needs independent study. The incentive recommendation emanates from agency theory, and the control theory does not strictly suggest incentive approach (Eisenhardt, 1985) except that input control is vital for the success of technology development projects (Johnson, 2011). Meanwhile, selecting competent evaluators from external environment may expose TTOs to information asymmetry. Hence, devising the right approach is vital through further study industry-university link for example. Hence, the contract type and the incentive system should be based on the tasks and outcomes expected from evaluators. Broadly, the evaluators will engage in selecting feasible projects and supporting technology developers to improve their projects. A contract type and incentive package of these elements needs further study.

Addressing financial incentives

The financial incentive for technology developers at the two S&T universities needs to be addressed. Empirical studies identified that lack of incentive adversely affects technology development and transfer outcomes (Kireyeva et al., 2020). Moreover, technology developers in this study stated financial incentives related objectives as a cause to involve in the technology development projects. Thus far, its absence has created a potential moral hazard associated with "misusing" per diem budget and potentially extending the duration of projects in order to acquire work overload benefits. TTOs perceive these potential moral hazards and have made decisions based on this premise during evaluation of budget proposal. This might be remedied by guaranteeing the outcome of technology development and advancing it to transfer ready prototype. The outcome-based contract type suits royalty or equity value incentive after commercialization or licensing (Jensen & Thursby, 2001). However, commercialization should be possible in the two S&T universities contexts. It depends on external stakeholders such as industry (Bozeman, 2000), technology, cost, and timing (see Stock & Tatikonda, 2000; Meseri & Maital, 2001; Heslop et al., 2001) among others, which are beyond the scope of this study. An additional study, however, is necessary to establish a comprehensive incentive package for technology developers.

Table 4 Summary of technology development actors' relationship, gaps, and solutions

Actors' relationship	**Actors' relationship features**	**Actors' relationship & influence on outcome -gaps**	**Solutions**
MoST/MoSHE (principal) and TTOs/ universities (agents)	- National proclamation (i.e., legal) of university establishment and reporting system (Lane & Kivistö, 2008)	- Activity control and finance/budget control are separated between two principals, overlooking the use of finance to attain the primary goal of technology development - Reporting system to MoSHE is exposed to information asymmetry, and potential moral hazard of deviating from shared goal by universities' TTOs - MoF employs line-item budgeting to control budget utilization to enforce rules and regulations are maintained in budget utilization	- Create an intermediary entity, a principal to the TTOs, to oversee both technology development performance and financial resource utilization - The entity should have close professional and institutional relationship to mitigate information asymmetry and moral hazard - Responds to financial resource utilization and procurement-related uncertainties of the technology development process by simplifying and customizing rules and regulations and prioritizing the needs of technology development
MoF (principal) and the universities (finance and procurement directorate) (agent)	- Audit, rules and regulation on budget utilization, finance reporting relationship (Eisenhardt,1989; Shapiro,2005)		
TTOs and finance and procurement directorates	- No control relationship but TTOs ensure financial utilization rules and regulations are maintained, through behavior-based contract with developers - TTOs oversee if technology developers' budget proposals and financial requests does not violate rules and regulations - Create layers of control system resulting in behavior-based contract (Kivistö, 2005) on budget utilization	- TTOs give priority for finance and procurement regulation needs over the needs of technology development -through behavior-based contract and control, creating an accountability paradox for TTOs - Finance and procurement-related rules and regulations created outcome uncertainty, hampering the enforcement of the outcome-based contract.	- As an extension of putting finance and university technology development oversight under one entity at the national level, at the institution level, TTOs should also incorporate decisions related to finance and procurement under their mandate to mitigate outcome uncertainties and ultimately enable outcome-based contract effectiveness. - With resource oversight, problems related to finance and procurement will be solved by prioritizing technology development outcomes.

Actors' relationship	Actors' relationship and gap	Actors' relationship & influence on outcome	Solutions and rationale
TTOs-principals and technology developers-agents	- Relationship managed with Written contract (Mahaney & Lederer, 2003) - Outcome-based contract on the technology development	- Technology development Skill gap of developers creating outcome uncertainty - Technology developers face challenges of collaboration from stakeholders, creating outcome uncertainty	- Apply clan socialization to build the skill and knowledge capacity of technology developers during technology development process - Engage stakeholders in workshops, seminars as clan socialization approach to create common goal among all stakeholders to minimize outcome uncertainties
TTOs and peer evaluators –no "full" agency relationship	- Peer evaluators evaluate and select projects on behalf of TTOs but there is no accountability-based agency relationship	- Lack of technical know-how during project evaluation creating information asymmetry - Lack of commitment from evaluators side	- Apply input control to hire qualified professionals from broader sources (local and international) to engage in the selection process of projects - Establish formal agency relationship based on control power of TTOs

Note: This table summarizes actors' relationships and their influence on outcome and solutions for gaps from the discussion and solution section of the paper

6.3. Improvements in the technology development procedure

The procedure of technology development will be changed as a result of the solutions forwarded to mitigate outcome uncertainties. Above all, the actors' current relationships will evolve to minimize the effect of outcome uncertainty factors. As such, the new intermediary entity at the national level and the TTOs at the university level will oversee finance and procurement decisions that fall within their jurisdiction. As a result, finance rules and regulations associated with outcome uncertainty elements will be easily mitigated.

Clan socialization will address additional gaps in technology developers' knowledge and skill and cooperation from stakeholders identified. The main feature of clan socialization is that it takes time for a system to improve and refine (Ouchi, 1980). As such, it will enhance capability of technology developers. Involving competent evaluators will assist project evaluation by addressing information asymmetry in the process. In the procedure suggested after introducing a new intermediary agency and expansion of TTOs mandate, the role of the actors practically changes, which is the main change in the procedure.

Accordingly, the technology development process will be altered in the following ways:

First, a call for project proposals will be announced for academic staff to submit projects.

Second, an evaluation of projects will be launched. The composition of project evaluators, selection criteria, and components of evaluation will change compared to the old procedure. Project evaluators are selected based on their expertise in research and technology development and experience on the particular technology they evaluate. The goal is to recruit highly qualified evaluators capable of effectively selecting projects and contributing to the project plan improvement. This will improve the information asymmetry caused by knowledge and skill gap of peer evaluators in the past. Moreover, projects should be evaluated based on merit for contribution to the technology development mission of the universities. The technical and finance evaluations should be combined, and technology developers should get support from finance and procurement experts in the TTOs to develop the budget plan.

Third, TTOs enter in to outcome-based contractual arrangements with technology developers. The upgrade from the previous procedure is that the contract should prioritize project outcome over finance and procurement related behavior-based contract.

Fourth, the technology development process will be launched. This phase was occupied by activity and financial reporting in the previous procedure. With the new recommendation, active engagement of the new national entity and TTOs is needed. Multiple activities should occur concurrently throughout technology development process. TTOs should facilitate the finance and procurement processes using its experts and manage them to ensure that services are delivered per the needs of technology developers. For materials, an agile procurement system should be implemented. This is possible since TTOs control finance and procurement experts in an agency relationship. In the previous system, the procurement experts were independent of TTOs in accountability. Hence, solving challenges regularly is possible, a departure from an old system.

Simultaneously, developers should be supported throughout technology development with technical knowledge and skill capacity-building initiatives. This should involve industry and external stakeholders to enhance knowledge, skill, and build stakeholder collaboration for developers. Collaboration with stakeholders will help technology developers mitigate the uncertainty of facing cooperation problems from stakeholders. This step is the epicenter for employing the clan socialization. Outcome uncertainty factors should be identified and improved regularly since clan socialization advocates improvements in the system continuously. Meanwhile, technology developers should be encouraged to exercise self-control and initiatives to address their challenges.

Additionally, the experts who evaluate the projects might participate actively in this process of this support system. The support system should create collaboration and encourage every stakeholder to contribute to the outcome. Applying clan socialization coupled with eased financial and procurement rules and regulations by the new national intermediary entity will address the manageability problem of projects. This will address the cause of moral hazard of TTOs' intention and practice to deviate from the university's mission in the scope of the technologies to be selected.

Fifth, technology developers deliver completed projects for review. Projects will be evaluated based on their outcome targets set with expert stakeholder. If improvement is needed on the technology development, it should be highly encouraged. Stakeholders and particularly potential technology users should participate in the process of outcome evaluation.

In sum, the improvement in the procedure from the previous one is not necessarily in shortening the number of steps in the procedure, but in the activities and actors involved in each step.

6.4. The potential contribution of research findings

This case study research has demonstrated how multiple principals and other agency ties involving technology development "complicate" the agency relationship and adversely affect the outcome and its measurement. This will fill the study gap identified by Rubens et al. (2017), which advocates for internal management and mission-related research analysis to identify problems associated with university-based technology transfer programs.

Moreover, the research has demonstrated in an African country context, the technology development challenges. The need to adhere to the national-level finance and procurement rules and regulations from MoF does not match the need for flexibility in the technology development process. Unlike the lack of financial resources identified in other African universities (Ssebuwufu et al., 2012; Göransson et al., 2009), utilizing it is the challenge in the two S&T universities in Ethiopia. Additionally, it demonstrated how a lack of knowledge and skill in technology development are barriers to the attainment of outcomes.

The findings complement the necessity to conduct "institutional level" and context-based problem identification and analysis for African countries' challenges with technology development in higher education institutions (Göransson et al., 2009, p.164). Additionally, the study contributes to the need for a study on the technology outputs of African universities compared to the "inputs" mobilized (Fadeyi et al., 2019, p.15). Accordingly, the analysis was undertaken by evaluating the operational and financial utilization and internal actors of technology development in this case study.

Finally, the supervisory ministries (i.e., MoSHE & MoF) have the same role on all public higher education institutions in Ethiopia. As a result, the findings related to such structure can be applied to other higher education institutions in Ethiopia with technology development, community service, and research projects.

6.5. Potential contribution for the theoretical lens used

A case study contributes to theory by "contradicting, challenging, confirming, generalizing, refining, revising, modifying, sharpening, adding detail to, specifying, expanding, or extending" on the theoretical components under consideration (Ridder et al.,2009, p.144). In explaining the relationship between empirical fining and theory, Ågerfalk (2014) explained that the former could be used to generalize about the latter or validate theoretical assertions through empirical facts.

This case study used mainly agency theory as a lens, and the variables were broad enough to explain the subject of the study. The existence of legal, hierarchical, reporting, contractual, and funding-based relationships among actors involved in the technology development process indicates that utilizing principal-agent theory was the right approach. Nevertheless, Whetten (1989) asserted that reaffirming the use of the theory is relevant, but it may not be considered a contribution to theory, hence not included here.

The contribution of the case study for the theory can be explained, first, from the context-based perspective of confirming previous empirical studies' contributions to the theory. The context can be explained as *to "where and when*" the theory may deviate in applications (Whetten, 1989, p.493). Meanwhile, what variable should be added and why it should supplement the contextual finding need to be addressed (Whetten, 1989).

Introducing principal's responsibility as a variable

In this case study, the first potential contribution is that principal's responsibility should be magnified as one agency theory variable. Researchers like Braun and Guston (2003) asserted that the need to focus on the principal's responsibility is given less focus in literature. As shown in this case study, TTOs used an outcome-based contract, and whenever the outcome "failed" because of outcome uncertainties such as skill gap, the outcome-based contract was not enforced. The TTOs could have facilitated capacity-building programs for technology developers, and supervisory ministries could ease finance and procurement regulations. Hence, the principal's role or performance should be one variable in enforcing the contract. In an agency relationship, the assumption is outcome-based contract minimizes the risk for the principal, and if there is a risk of failure, outcome-based contract favors the principal (Lasser & Kerr, 1996; Eisenhardt, 1989). However, this assumption should be moderated by the fact that the principal's contribution and performance expectation should be set clearly as a variable.

Setting the principal's responsibility, apart from controlling the agent (Braun, 1993), enhances the practical contribution of the agency theory. This is important for the practical purposes in public institutions setting, addressing the "where" of contribution for the theory (Whetten, 1989). Kivistö (2005) asserted that an outcome-based contract is disadvantageous if outcome uncertainty is high for an agent. This assertion would be correct, especially if contracts are enforceable, such as in a market setting. However, as the public institutions, the principals (i.e., TTOs) of the two S&T universities did not enforce the outcome-based contract since they recognized the uncertainties were the challenges. The principal's role in managing the uncertainty factors is determinant for the success of outcome-based contract in this case. In this research, this gap of the theory is filled by using clan socialization.

Meanwhile, setting the principal's responsibility does not violate the assumption that the principal's goal should be given priority. Incorporating the role and responsibility of the principal as a variable will give more meaning to the assertion that principal and agent engage in a “cooperative action” as stated by Eisenhardt (1989, p.59). However, precaution is necessary for putting principal’s responsibility as a variable. This is because the agent might "blame" lack effort from the principal when he or she is engaged in "shirking.”

Confirming the need of principal’s control of resource

The second contribution emphasizes that an agency relationship revolves around a specific decision issue (McGuire, 1988; Ross, 1973). Hence, the principal gives the right to decide on the specific area to the agent and retains the right to control the agent (Braun, 1993). However, Braun and Guston (2003) assert the components of the decision that the principal should make need to be given emphasis in literature.

An agency theory assumes the principal's goal should be given a priority, and the agency relationship contract should be set in the way it maximizes the principal's interest (Bergen et al., 1992; McGuire, 1988) by mobilizing resources to the agents (Braun, 1993). This case study has confirmed, as it is contribution to the theory (Ridder et al.,2009), that it is not only the contract type but who "control" the resource and makes rules and regulations on resource utilization matters to attain the main interest of the principal. As a contribution to the theory, this case study gives details (Ridder et al., 2009) on how principal’s control of resource is critical in an agency relationship.

In the case study, two principals, MoST/MoSHE and MoF, have been overseeing the technology development by the former and finance by the latter. TTOs gave priority for the goal of the principal controlling the resource, MoF, over the main mission of technology development and outcome, an interest of MoST/MoSHE. The solution section proposed the merger of the two decisions under the mandate of one principal along the national and university level hierarchies. The solution further suggested that the control on resource utilization submit to the priority goal of the technology development. Hence, the study contributed to the need to magnify the assumption that a principal should control the resource to ensure priority of the goal and execution of the contract. This confirms the assertions of Braun (1993) that principals use resources to shape their interest.

6.6. Limitation of the study

The research was limited to technology development initiatives, and the analysis and discussion centered on the projects in the two S&T universities. For instance, the research did not discuss the contract type between the MoF and the finance/procurement directorates in detail. Hence, the analysis and discussion were limited to how the actors were associated with the technology development process.

Moreover, the study was limited to the technology development activity of the two S&T universities and not the transfer aspect of the process. This is because technology development outcome is vital for technology transfer, and gaps were found in this process. However, technology development's diffusion and commercialization aspect require further research once the technology development process and actors can attain the output/prototype they target. The technology transfer and commercialization process might change the relationship among actors if, for instance, the technology developers have options of taking it to industry or when TTOs of the two universities start to specialize in commercialization (Bozeman, 2000). The solutions forwarded for the gaps identified are based on the assumption that future projects will also focus on copying or modifying existing technologies.

Moreover, incentives and cost associated with the solutions forwarded also need further study and their impact is not included in the solution context, which are vital in an agency relationship nevertheless (McGuire, 1988; Pratt & Zeckhauser, 1986). The practical implementation of the solutions also needs national level decisions by entities such as Council of Ministers to establish a new intermediary entity. The solutions in general are driven from the theories employed perspective in this research, and hence multiple study needs are mentioned to precede their implementation.

The research also dropped some technology development projects from the study. There were technology development projects MoST awarded to ASTU and AASTU staff members. There were also research projects that resulted in technology prototypes. The project developers were interviewed but not included in this study because their management was not under TTOs but rather under MoST and university research directorates. Nonetheless, these project developers shared the same interaction with finance and procurement directorates as technologies developed through TTOs and included in this study. Hence, the findings in this research can be used as a springboard for further study on those projects which are not included here.

The study obtained information from university-level technology developers and officials but could not incorporate MoST/MoSHE and MoF officials' and peer evaluators' opinions. As a result, the possible information asymmetry in TTOs' reporting systems and peer evaluators' knowledge and skill gap were not identified directly from ministries and peer reviewers of technology development projects. The information asymmetry and moral hazard related to these actors were mentioned as "potential" occurrences since they were not identified by triangulating the information from all parties.

6.7. Future research agendas

This exploratory case study has limitations and findings that necessitate further study. An exploratory case study contributes questions and develops hypotheses for further research (Ridder et al., 2009). Multiple further research needs are mentioned in the conclusion section of this paper to mitigate the limitations. Moreover, this study identified further research agendas based on the findings.

The first potential question is: how is the relationship between MoF and public higher education institutions managed in Ethiopia? Detailed research is required on the link between the MoF and Ethiopian Higher Education Institutions (HEIs), including the rules, regulations, and financial systems Vis-à-vis university missions. This is critical, as adverse reports characterize the overall relationship between HEIs and the MoF. For example, a national newspaper, the Reporter, reported that national members of parliament were "upset" with the auditor general's regular reporting of "financial irregularities," and HEIs were named as one of the top three federal government institutions unable to rectify irregularities (Abiye, 2017). The newspaper then published a story titled "universities under audit microscope" (Seyoum, 2017). On March 20, 2021, the newspaper quoted procurement agency officials claiming that "management and procurement problems in Ethiopia have reached an alarming level," with HEIs at the forefront of the story. As a result, it is worth studying the link in greater detail using agency theory and beyond.

There is additional premise to suggest this research agenda. Universities have various programs for which budget is allocated (such as academic, research, construction, technology transfer, and community service). The assumption is irregularities in few programs or few institutions could have resulted in the "blanket" restrictive financial rules and regulations on other programs such as research and technology development. Moreover, this affects the budgeting, utilization, and incentive systems depending on the findings. The practicability of solutions forwarded in this study to merge financial and operational decisions under an intermediary agency and TTOs will be cemented by findings from answering this question.

The second question to answer is how can an intermediary agency be established to fund research and innovation projects in Ethiopian higher education institutions? Easing and customizing funding rules and regulations are critical measures based on the findings of this study for the success of technology development projects. Establishing an intermediary agency to solve the problem is derived from theoretical perspective of the study. Hence, the breadth and practice of research and innovation in Ethiopian institutions should be studied to materialize it. The expanding research and technology development programs in higher education institutions favors introducing intermediary funding agencies for research and technology development. Such national institution establishment could also require the Council of Ministers' decision, which needs further study.

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Appendix 1

Community service and technology transfer budget, ASTU in *birr**

Year	Budget /expenditure	Community service (CC) and Technology Transfer (TT).	Budget utilization % (CC & TT)
2014/15	Budget	7,236,651.00	52.6
	Expenditure	3,808,573.06	
2015/16	Budget	28,591,700	
	Expenditure	5,358,526.55	18.7
2016/17	Budget	33,852,610	
	Expenditure	10,551,439.65	31.2
2017/18	Budget	28,192,610	
	Expenditure	7,969,296.23	28.3
2018/19	Budget	29,855,600	
	Expenditure	8,538,330.36	28.6
2019/20	Budget	33,055,247***	12.3
	Expenditure	4,054,245.55	
2020/21**	Budget	24,716,690***	-
	Expenditure	3,529,765.15	

* Source of data is Finance directorate office ASTU
**covers only 6-month report
*** The drop in budget from 2019/20 to 2020/21 is a decision by MoF for the low level of budget utilization, an adjustment made every five years (A1).

Appendix 2

Line-item budget 2020/21 partial data, ASTU

	code		
Public Institutions	Title Code	373	Adama science and technology university
Program	Subtitle	5	Consultancy and community service
Activity*	Sub-Subtitle	1	Research output Technology Transfer and consultancy service
Sub-Activity	Sub-Sub-Subtitle		
Project	S.S.S.S.S Title		

Source: finance directorate, ASTU
Note: budget codes used by MoF
*The activity was called Research output Technology Transfer and consultancy service and since 2015 it is renamed as Technology transfer and Community Service. The MoF is using the old activity name.

			Source of Finance			
Budget category	Narrative	total	Treasury	Income	aid Amount	Aid code
1	2	3	4	5	6	7
6230	Travel and Accommodation Service	3,425,190.00	3,425,190.00			
6231	Per Diem	1,857,260.00	1,857,260.00			
6232	Transport Payment	836,550.00	836,550.00			
6233	Accommodation	758,380.00	758,380.00			

Source: finance directorate, ASTU
Note: partial budget category in line-item budgeting (i.e. budget items 6230-6233) used by MoF for 2020/21 ASTU budget

Appendix 3

Technology development Project and officials’ category

Project &officials’ categories	**ASTU**	**AASTU**
Self-initiative projects	P2,P3,P5	P13
On progress projects	P3,P4,P5,P7,P9	P10, P13
Completed projects*	P1,P2,P6,P8	P11,P12,P14
IT related projects-output is software or program	P4,P7	P13
Electrical/Mechanical/Auto related projects – output is a physical prototype	P2,P3,P5,P6,P8,P9	P10,P11,P12,P13
Mixed (electrical and IT) projects	P1	
COVID related projects	P4,P7	P10,P11,P12,P14
TTO related officials and university Top management	F1,F2,F3	F5 ,F6
Administrative officials (Procurement and Finance)	A1, A2	A3
Coordinator during transition in 2014/15	F4	

Note: *Completed project represents project which consumed their budget fully

Appendix 4

An illustration of the procurement system and its impact on a project

A TT project was initiated in late 2017 in ASTU to make an electric three-wheel "*bajaj*" car by the academic staff from the automotive program. In order to implement the project, the team needed a scrap body of the three-wheel cars without the motor part of it. The body part was cheap, and it can be found in the scrap sales market. However, the Procurement and Property Administration agency allows purchases from registered companies on the agency's website, and the sellers should usually be Value Added Tax (VAT) registered and produce a receipt for the money paid. Moreover, these companies sell the new three-wheel cars and not the body part alone. Hence, the only option was to buy the three-wheel car itself. Nevertheless, the agency regulation also states that any kind of “car” can only be purchased at the national level through the agency in an open bid, and the MoF should approve the purchase first even for that to happen. The agency makes car and other purchases through bulk buying after collecting all the purchase requests from federal institutions.

Hence, the university top management requested to purchase with special permission and after more than a year of back and forth and waiting, MoF allowed the University to purchase an open bid and notified the agency. Later, when the agency notices the project will disassemble the car before the procurement was made, it notified the university that "no change" can be made on the car. Hence, during auditing, all the parts of the car should be accounted for as it were bought. However, the project needs only the body part, and the objective is to replace the engine with an electric system. The negotiation to get permission to make such changes is on the process, and the project is in its third year, delayed by more than two years. Even if permission is granted, adjusting to the current price of a three-wheel car will require another lengthy process involving the MoF all over again. This project exemplifies how actors interact and create outcome uncertainty on timely completion of the project.