ASSESSMENT MODEL OF UNIVERSITY INNOVATION ECOSYSTEMS IN ASEAN

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น.ส.จิระวรรณ ไชยพงศ์ผาติ

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต
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Thesis Title	ASSESSMENT MODEL OF UNIVERSITY INNOVATION ECOSYSTEMS IN ASEAN
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จิระวรรณ ไชยพงศ์ผาติ : แบบประเมินระบบนิเวศนวัตกรรมมหาวิทยาลัยในอาเซียน. (ASSESSMENT MODEL OF UNIVERSITY INNOVATION ECOSYSTEMS IN ASEAN) อ.ที่ปรึกษาหลัก : รศ. ดร.ณัฐชา ทวีแสงสกุลไทย, อ.ที่ปรึกษาร่วม : ผศ. ดร.จรสวรรณ โกยวานิช

การวิจัยเรื่องแบบประเมินระบบนิเวศนวัตกรรมมหาวิทยาลัยในอาเซียน พัฒนาขึ้นเพื่อสำรวจข้อมูลของแบบประเมินระบบนิเวศนวัตกรรมมหาวิทยาลัยในอาเซียน เนื่องด้วยประเด็นการศึกษาเรื่องแบบประเมินระบบนิเวศนวัตกรรมมหาวิทยาลัยในอาเซียนยังคงขาดแคลนข้อมูลที่ทันสมัยและต้นแบบที่ใช้การได้ในทางปฏิบัติ (Thawesaengskulthai et al. 2020) ซึ่งนำมาสู่วัตถุประสงค์การวิจัย ดังนี้ 1. เพื่อพัฒนากรอบแนวคิดเบื้องต้นในด้านการประเมินนิเวศนวัตกรรมที่ใช้ในมหาวิทยาลัย 2. เพื่อทดสอบและกลั่นกรองการประเมินผลที่ใช้ภายในมหาวิทยาลัย สำหรับผู้เชี่ยวชาญด้านนวัตกรรมและผู้มีส่วนร่วมต่อองค์กร ทั้งภาครัฐบาล องค์กรไม่แสวงหาผลกำไร และผู้ประกอบการเอกชนในภูมิภาคเอเชียตะวันออกเฉียงใต้ 3. เพื่อประเมินผลความเที่ยงตรงด้านเจตคติต่อโครงสร้างและความสัมพันธ์ที่เกี่ยวข้องภายในภูมิภาคเอเชียแปซิฟิก และ 4. เพื่อพัฒนากระบวนการรูปแบบเพื่อการค้าและพาณิชย์

โดยการวิจัยครั้งนี้ใช้ระเบียบวิธีวิจัยแบบผสมผสาน ดังต่อไปนี้ 1. การใช้เทคนิคเดลฟาย (Delphi Technique) เก็บข้อมูลจากกลุ่มตัวอย่างจำนวน 40 คน 2. แบบสำรวจความเห็นจากผู้เชี่ยวชาญ (Expert survey) จำนวน 418 ท่าน 3. แบบทดสอบด้านเจตคติ (Nomological testing) จากผู้เชี่ยวชาญจำนวน 459 ท่าน เก็บรวบรวมข้อมูลระหว่างปี พ.ศ. 2563 – 2564

ผลการวิจัยครั้งนี้ พบว่าแบบประเมินด้านนิเวศนวัตกรรมในมหาวิทยาลัยแห่งอาเซียน (ASEAN University Innovation Ecosystem Assessment: AUIEA) สามารถนำไปใช้เพื่อเป็นกรอบแนวคิดเบื้องต้นในการพัฒนาได้โดยปรากฏ 91 ตัวบ่งชี้ในการพัฒนาทั้ง 4 ด้าน ได้แก่ 1. ผู้นำและผู้บริหาร (Leaders and Governors) 2. ผู้ให้การศึกษา (Educators) 3. นวัตกร (Innovators) 4. ผู้เชื่อมต่อ (Connectors) เมื่อนำข้อมูลมาเพื่อสกัดเข้าสู่การสร้างกรอบแนวคิดพบว่ามี 64 ตัวบ่งชี้สำคัญ และเมื่อทำการตรวจสอบซ้ำด้วยแบบทดสอบด้านเจตคติในแบบสำรวจผู้เชี่ยวชาญเพื่อประเมินผลความเที่ยงตรงด้านเจตคติต่อโครงสร้างและความสัมพันธ์ที่เกี่ยวข้องภายในภูมิภาคเอเชียแปซิฟิก พบว่ามีผลลัพธ์ที่คล้ายคลึงกัน ทั้งในด้านผู้ให้การศึกษา นวัตกรและผู้เชื่อมต่อ ในขั้นสุดท้าย สำหรับการพัฒนากระบวนการรูปแบบเพื่อการค้าและพาณิชย์สามารถเป็นไปได้ด้วยการพัฒนาด้านเว็บไซต์และบริการการให้คำปรึกษาการใช้เครื่องมือแบบประเมินด้านนิเวศนวัตกรรมในมหาวิทยาลัยแห่งอาเซียนต่อไป โดยงานวิจัยชิ้นนี้ถือว่าได้บรรลุวัตถุประสงค์ในการศึกษาทั้งด้านการใช้งานด้านการค้าและพาณิชย์และด้านวิชาการ

สาขาวิชา	ธุรกิจเทคโนโลยีและการจัดการนวัตกรรม (สหสาขาวิชา)	ลายมือชื่อนิสิต ....
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Jirawan Chaipongpati : ASSESSMENT MODEL OF UNIVERSITY INNOVATION ECOSYSTEMS IN ASEAN. Advisor: Assoc. Prof. Natcha Thawesaengskulthai, Ph.D. Co-advisor: Asst. Prof. Jarotwan Koiwanit, Ph.D.

This study is concerned with the development, testing, and commercialization of an assessment model for university innovation ecosystems, for use in Asian universities. The research was motivated by a combination of two key issues, including the relatively new introduction of innovation as the university objective in Asian universities, and the lack of inward-focused, development-oriented models for university innovation ecosystems. The assessment model is designed to both standardize innovation ecosystem assessment, and provide internal developmental information for universities on a path toward innovation and entrepreneurial universities. The preliminary assessment was developed through reference to several existing innovation ecosystem assessment models, which were evaluated for their application to current innovation ecosystem standards and expert consensus. In the primary research, an assessment model was tested and refined using a multi-stage process, which included a Delphi stud (n = 40) an expert survey (n = 418), and nomological testing (n = 459) using a second expert survey, followed by development and validation of an assessment rubric using university case studies (n = 3). The Delphi study established an instrument that included 91 items distributed across four dimensions (Leaders and Governors, Educators, Innovators, and Connectors). The expert survey, which was analyzed using structural equation modeling, reduced the number of items to 64, while confirming the model structure. The nomological testing confirmed the model structure. The validation case studies illustrated it could be used in practice. Thus, the model, formally called the ASEAN University Innovation Ecosystem Assessment (AUIEA) model, was found to be satisfactory. Given these satisfactory results, the second half of the research was developed to questions of implementation, including website development planning, a business model, and business plan. The business plan is targeted to use as the final model as the basis for innovation consulting in the educational sector, offering basic or enhanced consulting services. Therefore the objectives of the study work, including through the development of the assessment model and the business model for its commercialization. The study’s implications include both academic and practical recommendations for assessment of university innovation ecosystems.

Field of Study:	Technopreneurship and Innovation Management	Student's Signature ....
Academic Year:	2021	Advisor's Signature ....
		Co-advisor's Signature ....

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Jirawan Chaipongpati

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CHAPTER I

INTRODUCTION

The entrepreneurial university is a recent evolution in the role of the university in public life, and it has made a significant impact on university activities, organization, and interactions between, and among individuals and institutions (Thawesaengskulthai et al., 2012; Thawesaengskulthai, 2018a; Thawesaengskulthai, 2019; Thawesaengskulthai et al., 2019). Despite this high profile of the concept, there has been surprisingly little research into how to measure the performance of the university's innovation ecosystem. The present research takes on this challenge by developing a performance measurement framework for innovation ecosystems, using Asian universities as the basis for the research. The study focuses on Asian universities due to their current stage of implementation of university innovation ecosystems, paired with the lack of Asian perspective on university innovation practices both in the academic literature, and in practice. Therefore, the study seeks to address an academic and practical gap in understanding how innovation occurs in the university, and what tools can be used to evaluate innovation ecosystems.

An innovation ecosystem is a complex system of activities and processes among and between organizations and individuals, which results in innovation activities, and eventually physical innovations (Jackson, 2011). The innovation ecosystem, which can be considered analogous to the natural ecosystem, is a complex system with multiple equilibria and many different agents or actors within it (Jackson, 2011). Universities serve as central hubs for innovation, and their innovation ecosystems arise from a complex set of interrelationships among various entities that draw upon human and material resources to develop new ideas and technologies (Jackson, 2011). Good innovation ecosystems can be established when a diverse range of participants foster learning, invention, collaboration, and value generation (Celuch et al., 2017). Innovation that leads to the development of Intellectual Property (IP) brings significant financial benefits to universities (Perkmann et al., 2011), but the innovation ecosystems of universities, when well-supported and managed, can also support the achievement of broader economic development goals (Jackson, 2011; Galan-Muros and Davey, 2019). Some universities have chosen the approach of the entrepreneurial university, in which university research activities are directed toward development and commercialization of activities in partnership with university external partners, such as private companies and government agencies (Etzkowitz, 2003). The entrepreneurial university is a relatively modern approach, developing from the university's traditional role as a producer of basic research (Etzkowitz, 2003). Thus, in the entrepreneurial university, the innovation ecosystem is focused on commercialization and innovation diffusion. Savetpanuvong and Pankasem (2014) suggest that universities should work towards transforming its innovation originator role to an innovation diffusion role, in an attempt to benefit from economies of scale and gain critical mass.

The performance of the university as a hub of a thriving innovation ecosystem has an increasingly important role in the university's reputation and competitiveness. An example of this importance can be drawn from the Times Higher Education (THE) global university rankings – the World University Rankings and the Global Impact Rankings. The World University Rankings, which address the performance of the university primarily from a learning perspective, incorporate innovation activities into its Research component (Times Higher Education, 2022a). The Research component, which makes up 30% of the total ranking score, includes elements of reputation survey (18%), research income (6%), and research productivity (6%) (Times Higher Education, 2022a). On this ranking, global leaders include the University of Oxford (United Kingdom), University of Cambridge (United Kingdom), and Harvard University (United States) (Times Higher Education, 2022b). In comparison, the top ranking Asian universities are Peking University (ranked 16th overall), National University of Singapore (ranked 21st), University of Tokyo (ranked 35th overall), and Kyoto University (ranked 61st overall) (Times Higher Education, 2021a). In Thailand, the top-ranked institutions including Mahidol University and Chulalongkorn University only rank between 600th and 800th, and 801st to 1,000th place (Times Higher Education, 2021a). Thus, by this ranking, while there are some strong research universities in Asia, there are also countries where there is a lot of catching up to do in terms of research outcomes.

In comparison, the Times Higher Education Impact Rankings use the United Nations Sustainable Development Goals (SDG) as the basis for ranking (Times Higher Education, 2022c). Of particular interest to this research is SDG9 (Industry, Innovation, and Infrastructure) which addresses innovation objectives. This measure is addressed through four dimensions, including research relevant to industry, innovation, and infrastructure (11.6% of the score), patents citing university research (15.4% of the score), university spin-offs (34.6% of the score), and research income from industry (38.4% of the score) (Times Higher Education, 2022d). This is a relatively simple measure, but it does include several aspects of innovation ecosystems. Globally, the top-ranked universities based on SDG9, with a shared first rank, include the University of British Columbia (Canada), Technical University of Munich (Germany), and Technical University of Twente (Netherlands) (Times Higher Education, 2022e). The top-ranked Asian universities, with a shared fifth rank, include Hanyang University (South Korea), National Cheng Kung University (Taiwan), National Taiwan University (Taiwan), and Yonsei University (Seoul Campus) (South Korea) (Times Higher Education, 2022e). There are also several other universities in China, Japan, South Korea, and Taiwan in the top 50 universities, along with the highest ranking ASEAN university (Chulalongkorn University in Thailand, ranking 26th) (Times Higher Education, 2022e). Therefore, Asian universities, particularly those from East Asia, do perform better in the SDG9 Impact Ranking compared to the overall university ranking, suggesting that their impact on innovation is out-sized compared to their overall research impact.

University rankings such as the World University Rankings and QS Rankings (a related ranking system) are highly relevant to undergraduate and postgraduate students, who use the rankings to narrow down their potential university choices from a wide array of domestic and international options (Bilton, 2018). University rankings are also part of the university's public reputation, which can affect public and private funding, research reputation, the ability to attract highly qualified teachers and researchers, and other outcomes (Simpson et al., 2005). Therefore, performance on these rankings overall, and on the individual components, does matter to universities.

However, the role of innovation ecosystems is not simply a matter of public reputation or admissions. For example, the establishment of university-university technology transfer networks may depend, at least in part, on the university's reputation for innovation and entrepreneurship (De Moortel and Crispeels, 2018). University innovation ecosystems and the associated innovation and commercialization activities may also have an impact on university funding, especially private sector funding on which many innovation activities are based (Ugnich, Chernokozov and Velichko, 2015). Universities also play a critical role in training entrepreneurs for the wider economy (Berger-de Leon et al., 2021). Berger-de Leon, et al. (2021), who evaluated entrepreneurship and innovation in Germany, argued that improving university participation in innovation ecosystems, and especially increasing the number of graduating founders and entrepreneurial spin-offs, was critical to supporting the national innovation ecosystem. Thus, there are several reasons for the university to be concerned about its innovation ecosystem, including its substantive effect on innovation, its role as a component in public reputation rankings, and its role as a facilitator of access to resources including technology transfer and access to funding for research and innovation activities. However, measuring innovation and entrepreneurship within the university may not be as straightforward as it is in a commercial organization for several reasons. Universities as organizations are characterized by a high degree of organizational complexity, including autonomous and decentralized planning and management (Kreysing, 2002; Malott and Martinez, 2006). At the same time, universities are centrally positioned within networks of cooperative innovation, creating a high degree of network connections and complexity as well (Patrucco, 2009; Trąpczyński, Puślecki et al., 2018). Thus, universities require a different approach to evaluating innovation than centralized and relatively simple corporations.

THE rankings and other university rankings are part of a broader global system of innovation rankings systems and indices, which are measured by a variety of institutions. Here, Thailand, which is one of the highest income countries in ASEAN, and as an upper middle income country, is representative of rapidly emerging Asia (World Bank, 2020), is used to illustrate how Asian countries often fare on these global competitiveness rankings. The first index considered, the World Economic Forum (WEF) Global Competitiveness Index incorporates national innovation ecosystems into its comparative competitiveness rankings (Schwab, 2019). The innovation capability pillar is one of twelve pillars within this ranking, which evaluates the extent of institution, policy and economic activity focused on innovation, incorporates university innovation ecosystems and their role in broader ecosystems. Schwab (2019) noted that most countries rank poorly on innovation capability, with only a quarter scoring above the midpoint in the range. The highest ranking countries in this area include Germany, Switzerland, the United States, and Taiwan (Schwab, 2019). Thailand is ranked 50th in innovation capability as of 2019, scoring 44 points, which is a slight increase from the previous year. This is higher than the global average of 38, but slightly lower than the East Asia and Pacific average (Schwab, 2019). The Global Competitiveness Index has not been calculated since 2019, which the WEF's 2020 Special Report on Global Competitiveness explained was due to the effects of the pandemic and the amount of uncertainty introduced into the global economy by this event (Schwab and Zahidi, 2020). Therefore, by the time this index is once again calculated this may be significantly different, particularly if Asian countries continue to work toward innovation capabilities.

Other relevant global innovation indices are the IMD World Competitiveness Ranking and World Digital Competitiveness Ranking, both developed by the International Institute for Management Development. The World Competitiveness Ranking uses investment in innovation as part of the basis for its rankings, but they do not break out the rankings based on this dimension (Institute for Management Development, 2021a). As of 2021, the most recent rankings available, the top-ranked countries included Switzerland, Sweden, and Denmark; the highest-ranking Asian countries included Singapore (5th), Hong Kong (7th), and Taiwan (8th) (Institute for Management Development, 2021a). Malaysia (25th) and Thailand (28th) were the most competitively ranked countries in the Association of Southeast Asian Nations (ASEAN) (Institute for Management Development, 2021a). The Digital Competitiveness Ranking obliquely addresses the innovation ecosystem, with its 52 factors addressing dimensions of training and education, scientific concentration, technological and regulatory frameworks and capital for technology, and adaptive attitudes (Institute for Management Development, 2021b). On this rating, the leading countries include the United States, Hong Kong, and Sweden, with other Asian countries including Singapore (ranked 5th), Taiwan (8th), South Korea (12th), and China (15th) also ranked highly (Institute for Management Development, 2021b). Malaysia (27th) and Thailand (38th) are the highest-ranked ASEAN countries on this scale (Institute for Management Development, 2021b). These rankings suggest that Asia is globally competitive, but not all countries have attained the same level of competitiveness and there is more room for improvement.

Although these rankings assess business competitiveness, this is not the only area where innovation is a concern. For example, the Notre Dame Global Adaptation

Initiative (ND-GAIN) Country Index evaluates readiness for climate change, as well as vulnerability to climate change (ND-GAIN, 2021). This index incorporates innovation as part of its social readiness component. Overall, Thailand is ranked 66th on this index, with its readiness ranked 66th (ND-GAIN, 2021). However, its social readiness (of which innovation is a part) is ranked only 74th, which is relatively poor in comparison (ND-GAIN, 2021). Furthermore, Thailand has slid by six ranked positions since 2019 (ND-GAIN, 2019), indicating it is not keeping up with either overall climate readiness, or social readiness for climate change. This is unfortunate, given that Thailand is one of the more vulnerable countries when assessing the effects of climate change, ranking 91st (ND-GAIN, 2021), which suggests it is not as prepared as it should be to address the potential impact of climate change.

Overall, these national competitiveness rankings indicate that Thailand is increasing in global competitiveness, including an increasingly high innovation capability. At the same time, it remains relatively low-ranked in some areas, and some of these, such as the ND-GAIN (2021) climate readiness rankings, suggest it may be losing ground. This mixed performance is not unusual for countries in Asia, particularly those below the first rank of high-income countries. Thus, it is worth considering how the university innovation ecosystem and its performance influences global business competitiveness, climate change readiness, and other long-term development needs. Since the university's innovation performance is a significant part of business and climate readiness, this represents a significant need to understand that performance.

The conceptual framework underpinned in an entrepreneurial university defined innovation as a significant instrument that every entrepreneur is awarded, but in a unique way to deliver the value (Savetpanuvong and Pankasem, 2014). The entrepreneurial universities are also given credit to help nations improve their innovation systems and enhance economies. However, past research shows that the concept of entrepreneurial universities operating in the form of normal universities, was largely criticized and not accepted (Slaughter and Leslie, 2001; Dharmajiva, 2017). With regard to this, a study concluded that traditional universities and entrepreneurial universities behave in different ways, as they are using different innovation ecosystem measurements and models. The researcher mentioned the existence of entrepreneurial universities as a source of hope among policymakers and no single concept can describe the framework of entrepreneurial universities (Dharmajiva, 2017).

1.1 Research Gap

The fundamental research gap that this study investigates is the lack of an up-to-date, practical conceptual model of university innovation ecosystem structure and assessment for use in Asian universities. Several previous measures have been proposed, either academically (Kirby et al., 2011; Guerrero and Urbano, 2012; Brennan et al., 2014; Guerrero et al., 2014) or by governments and non-governmental organizations (NGOs) concerned with education and innovation (OECD, 2012; National Science Technology and Innovation Policy Office, 2018). These have typically built on earlier commercial innovation models (Godin, 2006; Brown, 2014; Denning, 2016), which did not assess the institutional context of innovation, and therefore were not usable on their own (Bessant and Tidd, 2015).

These university innovation assessment models, collectively, are both useful and problematic. All of the models have a wide perspective on the factors that contribute to the university innovation ecosystem, and typically they address several different factors. However, they also tend to be extremely formal and procedurally driven, ignoring informal research networks and relationships, student experience factors, as well as other factors. They are also output-driven rather than process-driven, offering little insight into development of the university innovation ecosystem. Furthermore, the models often do not offer explicit measures. These models are also relatively older and may no longer reflect the structure of the university innovation ecosystem or its implementation at the university. Fundamentally, they also all suffer from the problem that there is no single definition of the university innovation ecosystem (Cheng and Shiu, 2015; Dharmajiva, 2017), and therefore no single way to measure it. The current research is intended to develop an up-to-date, inclusive and less procedure-driven model of university innovation ecosystem development to address these gaps in the existing research.

The secondary research gap is that all of the existing models were developed in the context of Western universities, typically either American or Western European. This is problematic because the role of research universities and their patterns of innovation is found to be different in Asian universities, due to different levels of innovation involvement and development of the innovative university model (Singh et al., 2015). For example, Asian universities typically have lower levels of patent issuance than American universities (Fisch et al., 2015). Thus, the outcome-driven measures developed for Western universities may not be appropriate for Asian universities.

1.2 Research Aims and Objectives

The main aim of this study is to develop a measurement and assessment tool for university innovation ecosystems in Asian universities. The research objectives and their associated research questions are summarized in Table 1. Each of these objectives is associated with a separate research stage or process, which is also summarized in the table.

Table 1: Research Objectives and Questions

Objectives	Questions
1. To develop a preliminary framework for university innovation ecosystem assessment based on existing theories and models and expert insights.	RQ1.1 What are the characteristics and features of existing university innovation ecosystem assessment models, and how do they apply to Asian universities? RQ1.2 What is the expert consensus on the innovative university in ASEAN?

Objectives	Questions
2. To test and refine the preliminary assessment using insights from university innovation experts in the university itself, and in partner organizations including governments, non-governmental organizations (NGOs) and private enterprise in ASEAN.	RQ2.1 What are the dimensions of the university innovation ecosystem? RQ2.2 What are appropriate measures to assess these dimensions?
3. To evaluate the validity of the nomological network of constructs and relationships, and investigate the validity of the proposed framework in the Asia Pacific region.	RQ3.1 To what extent does the university innovation ecosystem assessment model developed in Objectives 1 and 2 apply in the broader Asia Pacific context, and across different samples?

Objectives	Questions
4. To develop an approach for implementing and commercializing the model that results from the research.	RQ4 How can the university innovation ecosystem assessment model derived in Objectives 1 to 3 be commercialized and distributed for use in Asian universities?

1.3 Scope of the Study

The unit of analysis of the research was the university as a whole. The key issue was the dimensions and relevant factors that contribute to the performance of the university innovation ecosystem. To assess these factors, the study drew on experts from universities (including policymakers, innovation specialists, educators and researchers), and from partner organizations, including governments, non-governmental organizations (NGOs) and private enterprise.

The geographic scope of the study was Asia, with the first two stages of the research limited to the ASEAN+3 countries. This group includes the ASEAN nations of Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam, along with other major Asian countries including China, Japan and South Korea. The third stage of the research, which tested the nomological validity of the model, increased the geographic scope of the study, including participants from across the Asia Pacific region (48 countries in total, accounting for around 13,578 universities, and other higher education authorities (HEAs) (Webometrics, 2019)), shown in Figure 1.

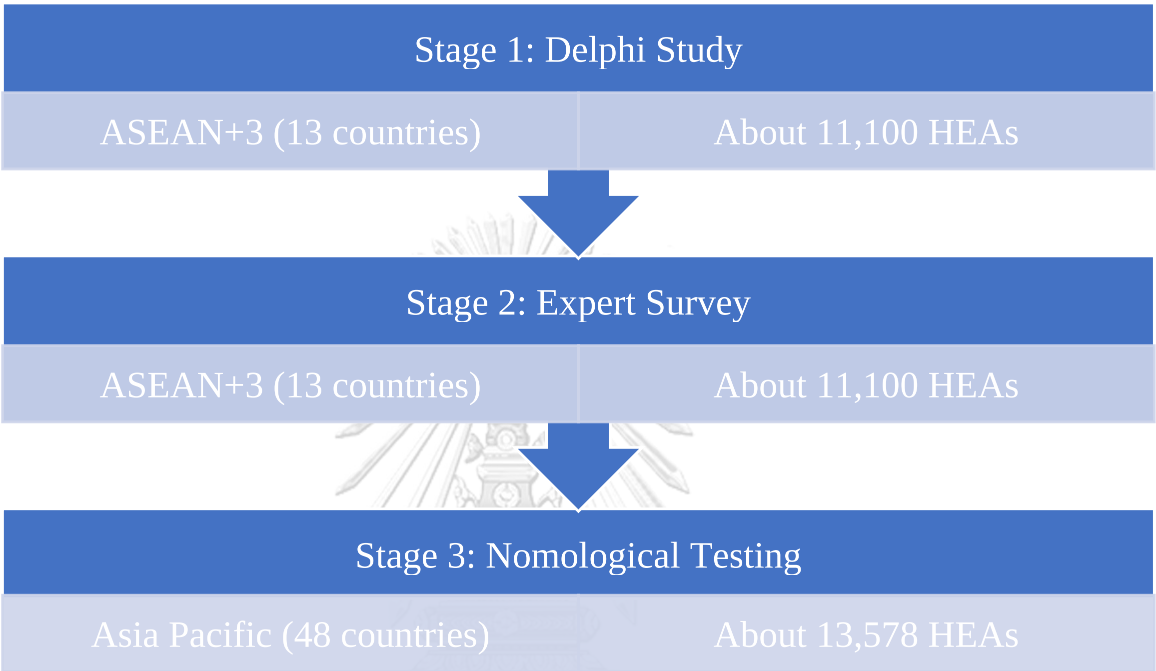


Figure 1 Geographic scope of the study

The scope of the research was confined to key components that contribute to the development and performance of university-based innovation ecosystems in selected Asian nations. As the study was centered on the university, other aspects that could influence the university's innovation outcomes, such as government policies, were excluded.

The time horizon of the study is cross-sectional, with most data collected during a single year (2020-2021). This imposes a limitation on the study's scope in that it does not assess changes in the measured phenomenon (Saunders, Lewis and Thornhill, 2015). For example, as university innovation ecosystems and their role in the overall innovation economy changes, it may be more appropriate to measure it differently, or different processes and characteristics may come to the fore. Thus, this model should be considered as a work in progress, not as a final model.

The output of the study is a final measurement and assessment instrument, the Asian University Innovation Ecosystem Assessment (AUIEA) framework. The framework was developed through several stages of research and is prepared for commercialization within the Asia Pacific. However, as will be explained in the conclusion, additional research is needed to test its validity and reliability for institutional settings outside the Asia Pacific region.

1.4 Research Contributions

This research will contribute to both the practical and academic literature. From the practical perspective, universities and other higher education institutions play a critical role within the broader innovation systems of the societies where they operate, and when academic innovation is managed successfully, it can contribute to national economic development and wealth generation (Jackson, 2011). Research that provides insights into successful innovation ecosystem management practices and evaluation strategies can therefore have practical benefits that go beyond higher education systems. Currently, the generalized models for assessing university innovation ecosystem structure and performance are aging, and most were developed outside the context of Asian universities and in a different period of university innovation. By developing an updated and appropriate model of university innovation ecosystem performance according to best practices and expert opinion, the research can contribute to university innovation ecosystem development by offering a way to effectively measure policies. Furthermore, the research also supports a path to commercialization for the assessment tool, which will offer universities a ready-made solution they can adopt and customize for their needs. Thus, the research provides both a model that can be implemented and a turnkey implementation process.

This research will also contribute to the theoretical academic literature as there is currently no single model for measuring innovation ecosystem performance (Cheng and Shiu, 2015). By incorporating elements that determine university-based innovation ecosystem success within a single theoretical framework, this research will provide a model that can be used by other academic researchers conducting innovation ecosystem studies. However, the model will be refined further, and as the results show, the current best practices and expert opinion on university innovation ecosystems does not completely align with the previously proposed theoretical models of the university innovation ecosystem. The theoretical aspects of the research, therefore, can support the direction of further study by identifying opportunities and areas of relative weakness.

1.5 Definition of Terms

Agents of change: Organizations, individuals, or mechanisms that facilitate changes in various aspects of university environments, including their cultures and practices, to promote innovation and entrepreneurship.

Connectors: Programs, organizations, human or mechanisms that connect individual innovators with mentors, universities, businesses, local and regional organizations, and/or communities.

Educators: Those who develop curricula; provide academic lectures, professional consulting, and training for innovative entrepreneurship; and establish and assess learning outcomes that support innovation.

Entrepreneurial university: A set of principles and practices for the organization and processes of the university to facilitate innovation and commercialization of innovations (Kirby et al., 2011).

Formal factors: Formal elements of the university, such as university structure, institutions and offices, curriculum, and support programs, which support innovation (Kirby et al., 2011).

Informal factors: Informal elements of the university, like attitudes, role models, culture and reward, that support innovation (Kirby et al., 2011).

Innovation: "… production or adoption, assimilation and exploitation of a value-added novelty in economic and social spheres; renewal and enlargement of products, services, and markets; development of new methods of production, and establishment of new management systems (Crossan and Apaydin, 2010, p. 1155)."

Innovation ecosystem: A web of interrelationships among actors and organizations seeking to promote innovation and new technology development, drawing upon various human and material resources to achieve these goals (Jackson, 2011).

Innovation relationships: Collaboration and cooperation between individuals and groups within the university and between universities, which form innovation networks to achieve innovation (Brennan et al., 2014).

Performance measurement: Indicators used for accessing the extent to which the organization or individual has met its goals (Richard et al., 2009)

Leaders and governors: Those who develop and implement vision, policies, and supportive programs/services for innovators.

Relationship builders: Individuals and groups within the university that develop and maintain internal and cross-boundary innovation relationships to innovation.

CHAPTER II
LITERATURE REVIEW

Although this study is a theory development project, it is building on a deep history of existing theories and empirical observations, regarding both innovation and its development, and also the role of the university in innovation. This chapter presents the literature review that was conducted on this theoretical and empirical research. The literature review used a traditional approach, with sources selected for their quality, relevance, and for empirical research currency (Efron and Ravid, 2019). The review draws on a range of sources, including academic journals and books, practice-oriented literature (especially for university best practices), and reports and guidelines from government and trans-governmental groups concerned with university innovation, as well as universities themselves. These sources reflect the breadth and depth of interest in university innovation systems, as well as the many different theoretical and academic perspectives that have been brought to bear on the role of universities in innovation.

The chapter begins with a discussion of the theoretical background of this research. Following a brief definition of the concept of innovation, the theoretical literature then moves through various models of innovation including classical and modern innovation models. Attention then turns to university innovation models themselves, which address the role played by universities. Following these theoretical models, the literature review then focuses on empirical research that has investigated the role of universities in innovation and the university innovation section, both in Thailand and in other countries (especially other developing countries). Case studies are then reviewed. The chapter concludes with a presentation of the conceptual framework, which was developed from this theoretical and empirical background. This conceptual framework serves as the basis for the primary research, the method for which is explained in Chapter 3.

2.1 Theoretical Background

2.1.1 Definition of Innovation

The core process at the heart of this research is that of innovation. The question of how to define innovation is a long-standing one, with many different definitions being offered from different academic disciplines and theoretical perspectives (Rogers, 1998; Crossan and Apaydin, 2010). As a result, there is no single consensus definition; for example, definitions may, consider innovation as process, outcome or both; address different means and stages of innovation; and consider different types and aims of innovation (Baregheh, Rowley and Sambrook, 2009). However, there are several definitions that are useful for the current perspective. One of these definitions takes a broad perspective on innovation as both process and outcome:

> "Innovation is: production or adoption, assimilation and exploitation of a value-added novelty in economic and social spheres; renewal and enlargement of products, services, and markets; development of new methods of production, and establishment of new management systems. It is both a process and an outcome." (Crossan and Apaydin, 2010)

A second definition, which was developed through an integrative process with definitions of different integrations and scopes, states that:

> "Innovation is a multi-stage process whereby organizations transform ideas into new/improved products, services or processes, in order to advance, compete and differentiate themselves in the marketplace." (Baregheh, Rowley and Sambrook, 2009)

Both of these definitions are relatively comprehensive, but while Baregheh, et al. (2009) did conduct a substantial amount of research for their integration, it is a reductive definition that only addresses the economic perspective on innovation. In contrast, the definition offered by Crossan and Apaydin (2010) specifically acknowledges the importance of social innovation. Furthermore, Crossan and Apaydin's (2010) definition addresses innovation as process and outcome, while Baregheh et al. (2009) only consider innovation as a process. Therefore, the definition provided by Crossan and Apaydin (2010) is more comprehensive and flexible. This research adopts the Crossan and Apaydin (2010) definition of innovation. It applies this definition of innovation across three categories of innovation models: classical, modern, and higher education specific models.

2.1.2 The Classical Linear Innovation Model

Development of the concept of innovation began in the early 2000s, with the introduction of the concept by economist Peter Schumpeter (1911) (Schumpeter, 1911; Godin, 2006; Greenacre, Gross and Speirs, 2012). Schumpeter's (1911) innovation theory was based on the action of individual entrepreneurs, who he depicted as moving through a three-stage process of invention (realization of an idea or concept), innovation (commercial application of the invention), and diffusion (spread of an innovation throughout the market) (Greenacre, Gross and Speirs, 2012).

Schumpeter's (2011) theory of innovation served as the basis for the development of the linear innovation model, which was prevalent up to the 1950s (Godin, 2006). As Godin (2006) explained, this model was gradually expanded to consider the actions of firms, research and development, rather than continuing to focus on a single inventor. Gradually, a three-stage process of innovation emerged, as modeled in Figure 2. Within this model, it is presumed that innovation begins with a process of basic research, which establishes key scientific principles (for example, a new material). Applied research then determines how it could potentially be developed commercially, followed by development, production and diffusion of new products (Godin, 2006).

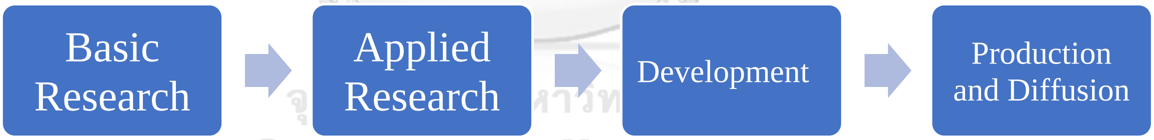


Figure 2 The linear model of innovation

(Source: Godin, 2006)

The linear model of innovation is still evident in some theories and practices. For example, the S-curve of innovation adoption proposed by Schumpeter (1911) was adopted by later innovation theorists to explain innovation diffusion (Rogers, 1962). However, as an innovation theory it has some limitations. The most important of these being, it does not have anything to say about the antecedents or causes of innovation

(Greenacre, Gross and Speirs, 2012). Instead, it is entirely about the commercialization of innovation, which is inadequate for the current research.

2.1.3 Modern Innovation Models

More recent advances in innovation theory have moved on from the simplistic linear innovation models and have begun to acknowledge the complex and dynamic nature of innovation and the importance of context. Models presented in this section are 1) Innovation System Model, 2) Innovation Ecosystem Model, and 3) Innovation Network Model.

2.1.3.1 Innovation System Model

A second modern innovation model is the innovation system model. According to one author, “The ‘innovation systems’ concept was introduced in the late 1980s to examine the influence of knowledge and innovation on economic growth in evolutionary systems where institutions and learning processes are of central importance (Brennan et al., 2014).” The initial proposal of the innovation systems model was national innovation systems, which investigated the emergence of innovation systems at a country level (Lundvall, 2007; Fagerberg and Srholec, 2008; Brennan et al., 2014). As Brennan et al. (2014) explain, broader application of the theory led to proposal of regional innovation systems (addressing the cross-border interactions of innovation actors across national borders) (Cooke, Uranga and Etxebarria, 1997); sectoral innovation systems (which investigate innovation systems with individual industries) (Breschi and Malerba, 1997); and technological innovation systems (which address innovation systems leading to innovation in a specific set of technologies) (Bergek et al., 2008). Thus, although innovation system theory was initially proposed to explain innovation at the national level, it can apply at scales that are both larger and smaller.

Although they apply to different innovation contexts, innovation systems theories are based on three distinct elements (Brennan et al., 2014). The first of these is components, or actors/agents within the innovation system and the boundaries between them. Actors in the innovation system can include “individuals and firms, higher education and research institutions, government agencies, trade associations, and other units making up the institutional strategy between them (Brennan et al., 2014).” The second element is the relationships between the system components or actors, for example knowledge combinations through technology transfer. The third element is the functions of the system, which are “the generation, diffusion, and utilization of the technology… [through capabilities including] i) selective (strategic) capability, ii) organizational (integrative or coordinating) capability, iii) technical or functional capability, and iv) learning (adaptive) ability (Brennan et al., 2014).”

The innovation system model can be applied to universities, as it is in the higher education (HE) innovation system theory (Brennan et al., 2014). Brennan et al. (2014) identify the specific elements of the HE innovation system, as shown in Figure 3. The functions of the higher education innovation system that Brennan et al. (2014) identify include education (teaching activities), research (research and innovation), and engagement with the community and society as a whole. This so-called ‘third mission’ is a wide-ranging form of engagement, which can include everything from involvement in government policymaking to engagement with private enterprise for innovation activities (Brennan et al., 2014). The authors used an actor-oriented perspective in identifying the relationships between them; an *actor* is any entity that is involved in the innovation system, either directly or indirectly (Brennan et al., 2014). Institutions (for example, research groups) can be involved as actors, but so can individual researchers and educators. Finally, Brennan et al. (2014) proposed that there were several kinds of relationships that actors could engage in during the process of the innovation functions. These could include relationships of collaboration and conflict moderation, in which actors worked together to achieve a common goal; substitution, in which actor relationships were designed to address resource gaps (for example, researcher relationships with private industry, providing industry with knowledge and researchers with funding); and networking (establishing less formal relationships for future use) (Brennan et al., 2014). Furthermore, Brennan, et al. (2014) noted that these networks are international, as university research is highly cross-border. Therefore, within this model of university innovation, internal and external institutional, and political boundaries are porous and can be crossed for the purposes of knowledge production and innovation (Brennan et al., 2014). This model of the higher education innovation system, therefore, addresses the relationship of the university in innovation as a dynamic and flexible set of relationships between actors, which facilitate the core functions of education, research, and engagement.

Higher education innovation system		
Functions	**Components**	**Relationships**
• Education; • Research ; • Engagement ('third mission').	• Direct and indirect actors; • Institutional and individual actors.	• Collaboration / conflict moderation; • Substitution; • Networking.

Figure 3 The higher education innovation system

(Source: Brennan et al., 2014, p. 37)

The innovation system model has some advantages for university innovation models. First, it changes the focus from the university as a whole (as in disruptive innovation) toward a component-based and dynamic approach, enabling the researcher to investigate where innovation is taking place, and what facilitates this innovation (Brennan et al., 2014). This goes beyond the national innovation system perspective, which considers universities as only one of the components in the entire system (Krishna, 2018). In practice, however, empirical application of innovation systems perspective is highly complex, and can be difficult to apply these models and derive any form of practical insight from this application (Bergek et al., 2008). This complexity emerges from the non-linear and dynamic nature of innovation systems, which make them very difficult to model properly (Greenacre et al., 2012). Even though the innovation system model is useful for understanding systems conceptually and if applied properly can have a strong empirical basis (Brennan et al., 2014), in practice it may be very difficult to apply directly.

2.1.3.2 Innovation Ecosystem Model

A refinement of the innovation system model is the innovation ecosystem model. The concept of the innovation ecosystem is not entirely stable, and has instead undergone several changes over time (Gomes et al., 2018). An innovation ecosystem can be broadly defined as a network of interconnected actors that cooperate formally and informally to create value through innovation processes (Gault, 2018; Gomes et al., 2018). Innovation actors can include individuals (for example researchers and educators), but it can also include groups (for example interdisciplinary or cross-institutional research groups) and organizations as a whole (for example, the entire university). It can also include a range of different actors, including universities, private organizations, and public organizations like government agencies and non-governmental organizations (NGOs) (Gomes et al., 2018). Gault (2018) further specifies that the main purpose of the network is innovation, or in order words development of new products and services, policies, processes, or organizations among other things. While the intention of innovation can be commercialization, it is not necessarily so; for example, innovation can also be oriented to domains such as government policy or non-profit organizations (Gomes et al., 2018).

The innovation ecosystem model is context-specific, meaning that the components that make it up depend on the organization type and context (Gomes et al., 2018). More specifically, a university innovation ecosystem is the network of internal and external relationships between actors in the university through which innovation activities are coordinated and facilitated (McConnell and Cross, 2019). The concept of external connections is critical, because unlike in other innovation models, the organization is situated in a broader context (Benitez, Ayala and Frank, 2020). In the case of a university, this broader context is national and international innovation networks, in which universities play several critical roles. These roles include training of researchers and scientists (Støren and Aamodt, 2010; Vlasov, 2021) and cooperating with other organizations, including interdisciplinary and inter-university relationships, and relationships with private companies, industries and government agencies, and other public agencies (McConnell and Cross, 2019). These networks of internal and external connections facilitate and promote research (Støren and Aamodt, 2010; Vlasov, 2021). They also facilitate the commercialization and use of innovations and knowledge derived from the university (Rasmussen et al., 2011; Fini et al., 2019), particularly by small and medium enterprises (SMEs) and other organizations that do not have in-house research and development (Getmantsev et al., 2020). Thus, the university innovation ecosystem can be broadly summed up as a multi-level network of internal and external relationships between actors, which facilitate the processes of innovation both now and in the future.

2.1.3.3 Innovation Network Model

The fourth modern model that was considered for this research was the innovation network model. This is the newest model that could be identified and is clearly based on previous research and findings. While innovation systems models focus on a complex set of interactions between actors (which could be institutions, individuals, or even technologies), innovation network models focus on the social interactions that create networks of relationships and their contribution to innovation (Acemoglu et al., 2016). In other words, the innovation network perspective focuses on the socio-organizational level of innovation, in which social capital is generated and turned into purposes such as innovation (Ahrweiler and Keane, 2013). Authors using innovation network models argue that it is social processes between actors in the network (which in innovation systems theory are called components and relationships) that generate innovation (Ahrweiler and Keane, 2013; Acemoglu et al., 2016). The innovation network perspective is a potentially highly useful model of innovation processes, but it faces challenges including formulation of a clear process model and the ability to reliability and validly test this model.

One of the problems of innovation networks is how to formulate a clear theoretical model of the process (Leydesdorff and Ahrweiler, 2014). Many authors who have used the theory of innovation networks have used standard social network analysis

(SNA) techniques to test the innovation network theory empirically. One example is that of Acemoglu et al. (2016) who applied SNA techniques based on shared citations and patent applications to identify network nodes and relationships between them. This approach is useful for enumerating relationships, but it fails at identifying deeper social structures and interactions that may occur without this proof (Leydesdorff and Ahrweiler, 2014). Thus, some authors have undertaken development of theories to explain these interactions.

One of these models is the multi-level innovation network (Figure 4) (Ahrweiler and Keane, 2013). This model proposes that there are three different levels of network interaction. At the concept level, different ideas and relationships are the basis for interaction. At the individual level, people within the network, their relationships to each other and their shared viewpoints influence the innovation process. At the socio-organizational level, the organizations (e.g., teams or companies) and their interactions are key to innovation. Actors between these different levels interact to generate and develop innovations (or to impede them).

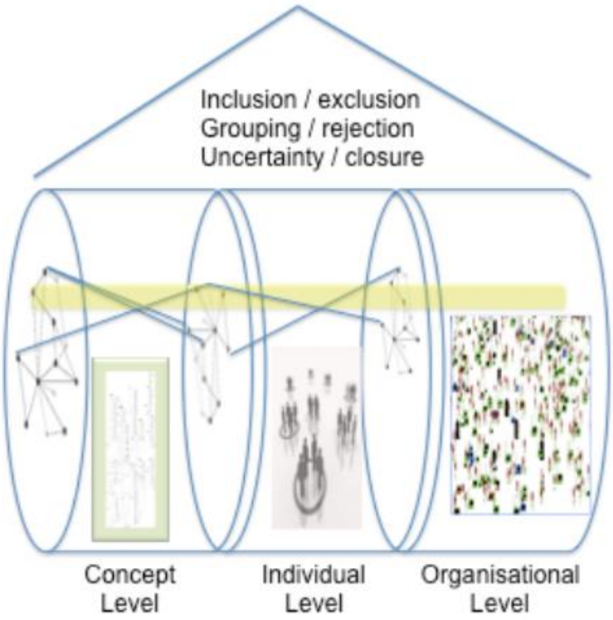


Figure 4 The multi-level innovation network framework

(Source: Ahrweiler and Keane, 2013, p. 79)

Another attempt to formulate an underlying theory for innovation networks was undertaken by Leydesdorff and Ahrweiler (2014). This formulation of innovation network theory was based on existing models, including social systems theory (Luhmann, 1995) and sociology of translations (Latour, 2007). This model argued that technological landscapes and self-organization of social interaction is a duality of structure which results in innovation through actors within the network (Leydesdorff and Ahrweiler, 2014). Thus, there are three levels to the network, including the observed trajectories of actor-network relationships, the latent objects that these observed trajectories represent, and the second-order translations between these trajectories and objects (Leydesdorff and Ahrweiler, 2014).

The innovation network model is a potentially compelling model for several reasons, including its strong representation of the socio-organizational level of innovation and the acknowledgement that innovation networks are not necessarily bound by organizational relationships, especially in knowledge production networks such as academia (Leydesdorff and Ahrweiler, 2014). At present, however, there is not yet a strong underlying theory of innovation networks, and techniques that have been developed, like SNA, are mainly focused on individual, observable interactions such as citation analysis. Thus, while innovation networks are a model that could potentially be more useful in future, at present it has theoretical and methodological limitations that mean it would not be a good basis for a strongly supported measurement model.

2.1.4 Entrepreneurial University Models

The general models of innovation systems and networks have been applied to the university context with the development of two entrepreneurial university models. These models can be characterized as the basis for organizational performance measurement systems. A performance measurement system can be defined briefly as an organizational approach to measuring efficiency and effectiveness of different activities, based on pre-selected performance criteria (Neely et al., 2005). To implement a performance measurement system, organizations must set objectives, identify measures and targets, and monitor activities against these measures and targets. A performance measurement system is not simply a single individual activity measure, but a full set of measures that are applied to different systems and processes within the organization (Choong, 2013). There are myriad potential measures that can be set for different types of processes, depending on the purpose of measurement; for example, they could include cost, time, and material efficiency of processes, output measures, headcount or labor efficiency, or other measures (Neely et al., 2005). The selection of measures is dependent on the performance objectives of the organization, and therefore different measures are appropriate for different organizations (Choong, 2013).

University innovation measurement models can be used for several different purposes. One of these purposes is outcome-oriented, assessing the role of the university in internal and external innovation and technological development (Ugnich et al., 2015; De Moortel and Crispeels, 2018). For example, such measures assess outputs like patent issuance, licensing and commercialization, which are objective external measures of the university's innovative outcome. This is certainly an important consideration in Asia Pacific countries including ASEAN, since universities are responsible for a significant amount of innovative output in the area (Celuch et al., 2017; Novela et al., 2021). However, it is only a partial measure of the economic value of innovation itself (Bendixen and Jacobsen, 2017), not reflecting the broader impact on sustainability, or other social and environmental contributions (Vlasov, 2021). From another perspective, the university innovation ecosystem measurement model should be developmental, investigating the current output *and* its facilitating processes to identify areas for improvement (Bittencourt et al., 2019). This is one area where most existing models, which are discussed below, are weak, as most are outcome oriented, rather than internally oriented.

Importantly, there is no single consensus model, or even a clear candidate, to measure or assess the entrepreneurial university. This is unlike other areas of educational quality, where models have been developed to assess, for example, student outcomes (Elken and Stensaker, 2018). The measures that have been proposed, for example, the innovation dimensions of university rankings (Bilton, 2018; QS, 2020;

Times Higher Education, 2021b), are typically market-oriented and outcome-oriented, focusing on proxy measures such as number of patents, or monetization of intellectual property rather than internal process measures. These measures are not necessarily indicative of university innovation ecosystem development in Asian countries, especially ASEAN, where university integration into national innovation ecosystems is a relatively new concept (Afzal et al., 2018; Novela et al., 2021). Thus, the models reviewed serve as a starting point, but as will be shown throughout the analysis, all have weaknesses in terms of their usability for measurement of the university's internal process and progress towards an integrated innovation ecosystem.

The models reviewed here provide guidance on appropriate performance measures to address activities and processes associated with innovation in the university. Key models include the entrepreneurial university development model and the entrepreneurial university framework. These models, which are relatively new in terms of innovation theories, are specifically designed for application at the university. At the same time, they draw on existing innovation models.

2.1.4.1 Entrepreneurial University Development Model

The first theory that is investigated here can be termed the 'Entrepreneurial university development model.' This theory is aimed, not just at describing how universities already participate in innovation, but at actively developing entrepreneurial capabilities in the organization (Kirby et al., 2011). These authors, who conducted some of the earliest work in this theory, observed that there are many different definitions of the entrepreneurial university, most of which emphasize the nature of the university as a technology and knowledge incubator, and commercializer of innovations. They used an institutional economics perspective to establish a preliminary model for entrepreneurial university development. They proposed a conceptual framework that included formal and informal factors that could influence entrepreneurial activities of the university, including teaching, research, and direct entrepreneurship activities (Kirby et al., 2011), presented in Figure 5.

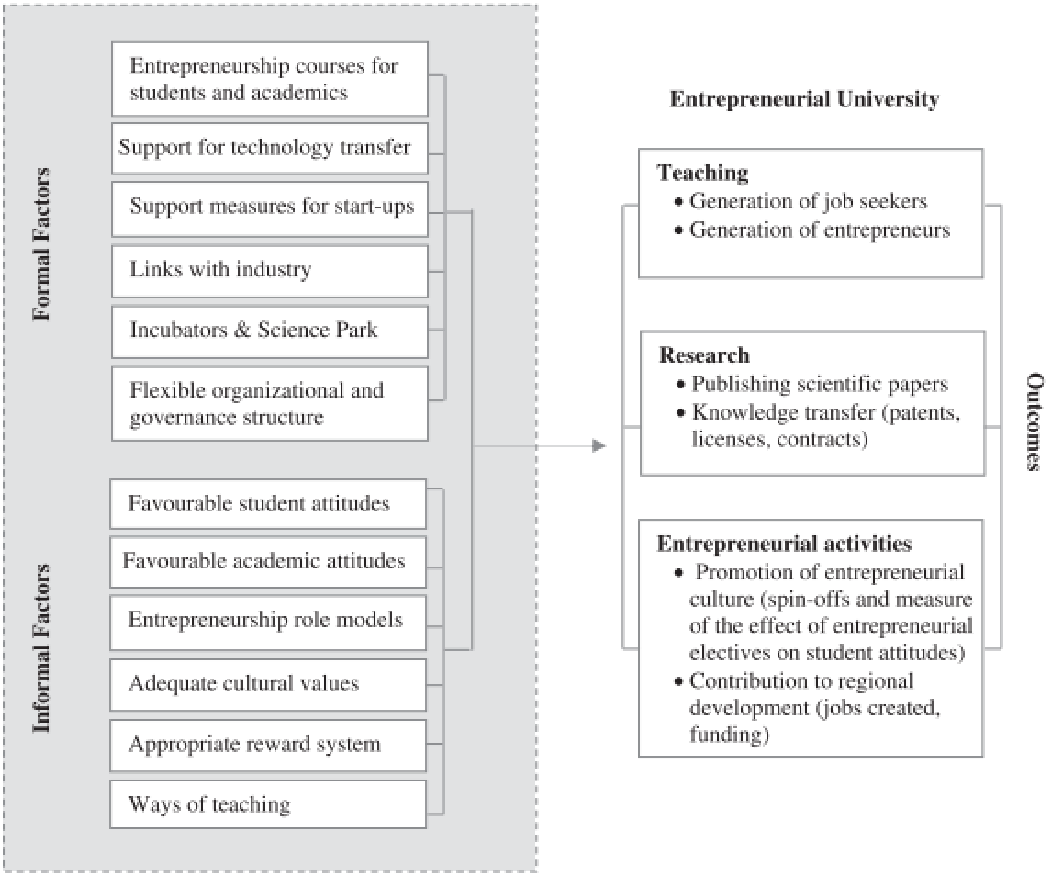


Figure 5 Conceptual model of entrepreneurial university development

(Source: Kirby et al., 2011, p. 312)

Later research has resulted in a more comprehensive entrepreneurial development model. One of these theoretical extensions included internal factors (resources and capabilities) along with the formal and informal environmental factors, to more clearly describe the environmental and internal context of entrepreneurship within the organization (Guerrero and Urbano, 2012), shown in Figure 6. Authors' empirical test of the model generated broad support for the refined model of the entrepreneurial university. They argued that the components of this model could be used to evaluate the university's performance as a facilitator of entrepreneurship, although they did not specifically identify a measurement approach. Another limitation is that the empirical work supporting this model was performed in a specific context of Spanish universities, which the authors acknowledge might not hold in a different cultural context (Guerrero and Urbano, 2012). Thus, even though this is a useful extension to the model, it has not completely described the situation.

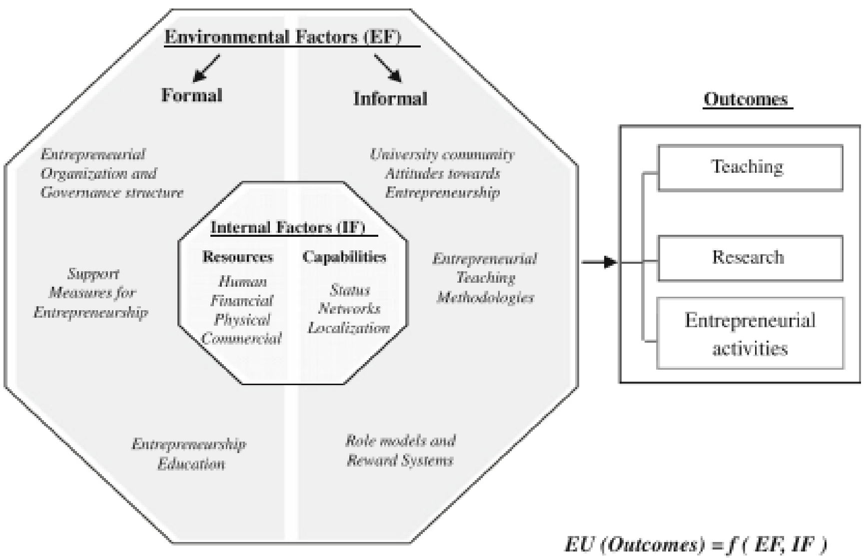


Figure 6 The entrepreneurial university development model (extended version)

(Source: Guerrero and Urbano, 2012, p. 49)

Despite the general usefulness of the entrepreneurial university development model as presented by Kirby et al. (2011) and Guerrero and Urbano (2012), there are some problems with it. One of these problems is the reliance on the notion of the so-called third mission, or the argument that universities have social, enterprise, and innovation responsibilities (Loi and Di Guardo, 2015). This third mission is an underlying assumption of both previous authors, leading to the assumption that universities should therefore be assessed on how well they achieve this aim (Kirby et al., 2011; Guerrero and Urbano, 2012). However, it is not necessarily the case that universities agree on exactly what this so-called third mission consists of, or even whether it is in fact an obligation of the university (Loi and Di Guardo, 2015). Thus, whether the assumption that this third mission is both accepted and perceived consistently by universities is a serious question when it comes to the entrepreneurial university development model. This inconsistency can be seen in the previous research that applies the entrepreneurial university development model which has had varying results (Guerrero et al., 2016). Authors of this paper attribute these varied results, at least in part, to a rapidly changing innovation landscape. For example, this could include increasing intensity of individual and organizational interactions, and the involvement of non-university research and development activities (Guerrero et al., 2016). The biggest problem with this model, however, is that this model is entirely internal to the university and its constituent organizations. As far as innovation models go, this characteristic reaches back to the linear innovation models, which did not acknowledge interactions between organizations (Greenacre et al., 2012). As the research on innovation networks show, the idea that innovation activities occur solely within university borders must be soundly rejected – in fact, there is a very high degree of inter-organizational and individual interaction across organizational boundaries (Ahrweiler and Keane, 2013; Leydesdorff and Ahrweiler, 2014; Acemoglu et al., 2016).

Thus, even though this model is comprehensive and clearly defined in terms of the internal conditions of innovation, it is inadequate in its consideration of external factors.

2.1.4.2 Entrepreneurial University Framework

Another innovation model considered is the entrepreneurial university framework (Figure 7). Unlike other models, the entrepreneurial university framework is designed for implementation at the university level to both implement entrepreneurship supporting activities, and measure them within the university (OECD, 2012). Accordingly, the model does not propose a new theory, but instead consists of an integration of existing theories and models. Similarly, the framework does not offer a definition of the entrepreneurial university, arguing instead that its dimensions can be applied across any definition in use.

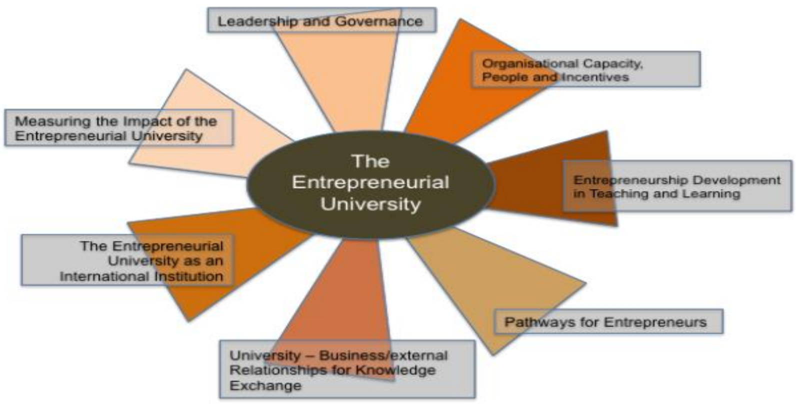


Figure 7 The entrepreneurial university framework

(Source: OECD, 2012)

There are seven dimensions of the entrepreneurial university framework (OECD, 2012). These dimensions include university leadership and governance;

organizational capacity, people and incentives; entrepreneurship development in teaching and learning; pathways for entrepreneurs; university-business or external relationships for knowledge exchange; the entrepreneurial university as an international institution; and measuring the impact of the entrepreneurial university. Each of these dimensions are characterized by several items, which can be used to evaluate the university. For example, key aspects of leadership and governance include:

> "Entrepreneurship is a major part of the university strategy… there is commitment at a high level to implementing the entrepreneurial strategy… the university has a model for coordinating and integrating entrepreneurial activities at all levels across the university… the faculties and units have autonomy to act… [and] the university is a driving force for entrepreneurship development in the wider regional, and community environment (OECD, 2012)."

Other dimensions have the same level of questions, with a 10-point rating scale followed by a paragraph of description on the ideal conditions under the ratings question (OECD, 2012).

The OECD (2012) entrepreneurial university framework is the most useful model of innovation within the university that can be identified for several reasons. First, it is a comprehensive and multidimensional tool, which addresses everything from leadership to measurement strategies. This means that it steps beyond the entrepreneurial university development model discussed above to evaluate much more comprehensive information. Unlike the entrepreneurial university development model, the OECD's (2012) model is also multi-level, considering the individual actors within the university, university and sub-organizations, and individuals and organizations outside the university boundaries. This draws on innovation systems and innovation network theories (as discussed above), which consider innovation as an activity that must cross organizational boundaries (Brennan et al., 2014; Leydesdorff and Ahrweiler, 2014). Last but certainly not least, the OECD's (2012) model actually includes a straightforward measurement and evaluation tool. This is unlike most other innovation models, which tend to be descriptive rather than evaluative, and do not provide a clear way to implement the model. Thus, this model is perhaps the strongest model for application to real-world evaluation of universities.

Despite these strengths, there are some weaknesses that can be observed within the model. One of these problems is that it focuses almost entirely on what are described as formal environmental factors and internal factors in the entrepreneurial university development model (Kirby et al., 2011; Guerrero and Urbano, 2012). This is clearly intended to standardize the subjective evaluation that is inherent in the study's use of Likert scale items (Brace and Krosnick, 2018). However, it also means that many different aspects of informal support for innovation, such as culture and interaction, are ignored. There are also functional problems with the measurement instrument, including that it's highly complex, subjective and relies on internal information that may not easily be available even for an insider. Thus, while this model is the best available, there are still some usability problems that need to be addressed.

The final model considered in this study is the innovation ecosystem model developed by Thailand's National Science Technology and Innovation Policy Office (2018). This model (Figure 8) was developed by reviewing a number of previous studies and existing entrepreneurial university frameworks. The model consists of 5 main dimensions which are; 1) Leadership & Governors, 2) Educators, 3) Innovators, 4) Connectors 5) Agents of Change. The factors included in each dimension are explained below;

Leadership & Governors: focuses on policy, vision plan, communication and governance.

Learning outcome: focuses on learning outcome, character curriculum and co-curricular evaluation.

Innovator: focuses on IP prototype, funding investment, training, IT regulation data and outreach.

Connectors: focuses on relationships with private and public companies, and community to create innovation and entrepreneur development.

Agents of change: focuses on the organization culture and structure management system.

This model covers a lots of essential factors for developing entrepreneurial universities. Thus, it is used as a baseline for developing a conceptual framework of this present study.

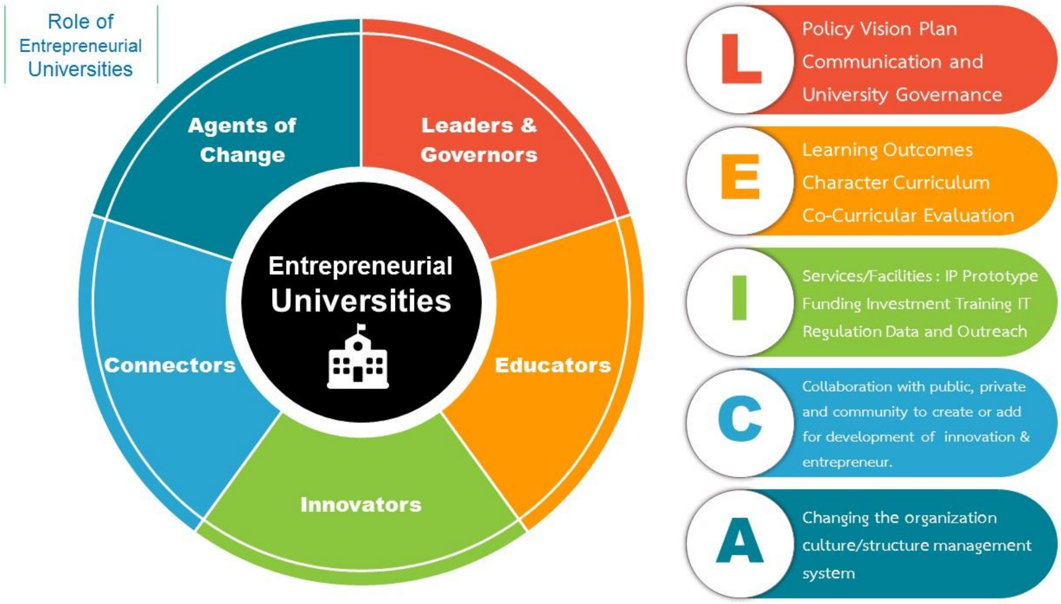


Figure 8: Entrepreneurial University (Thawesaengskulthai, 2018b; 2020)

2.1.5 Summary of the State of Existing Innovation Models for Universities

The previous sections have shown that innovation models for universities, although they are relatively new, have been in the making for over a century. The earliest linear models of innovation, developed by Schumpeter (1911), and in use up to the mid-20th century, proposed that innovation was an individual activity of entrepreneurs. The Baldrige model of innovation, which was popular up to the late 20th century (although it has now become mostly irrelevant) drew on this linear tradition of innovation, employing it as part of the quality excellence model, although it was not clearly explained. Moving into the 21st century, models such as the disruptive innovation model, innovation systems model, and innovation network model created a much more complicated picture of innovation as, not the work of a single individual or organization, but of a complex, dynamic and nonlinear interaction at the socio-organization level. When applied to the university, these models demonstrated that innovation could have a social goal. Furthermore, it demonstrated that innovation occurs between multiple actors (or components) in different organizations, and frequently reached across organizational borders. Thus, these models are useful for moving the context of innovation outside the bounds of a single network. The establishment of a so-called third mission for innovation, which made innovation support an explicit responsibility of the organization, is the basis for the university-specific innovation models, including the entrepreneurial university development model and the entrepreneurial university model. These models incorporate multiple factors in their explanation of how the university as an organization contributes to innovation. However, as discussed above, both of these models have some significant theoretical and practical gaps. Thus, the present study is designed to build on these existing models to develop a new measurement model that can overcome these gaps.

2.2 Stakeholders in Entrepreneurial Universities

The previous section reviewed existing models of entrepreneurial universities to establish the strengths and weaknesses of these theories and how they can be improved. As a means of moving forward toward this improvement, the empirical research was investigated to identify university factors that contributed to the university innovation ecosystem. The five factors identified include leaders and governors, educators, innovators, connectors and agents of change

2.2.1 Leaders and Governors

Leadership, governance, and management activities within the university are distinct, but related to institutional logics of communication, direction, and control (Blaschke, Frost and Hattke, 2014). As Blaschke et al. (2014) demonstrate, the domains of these activities are distinct; leadership is responsible for strategic direction and vision and establishment of policies, governance relates to oversight, and management is related to direction and control. However, Blaschke et al. (2014) do share certain micro communication practices involved with agenda building, critical reflection, devising policies and procedures, and debriefing regarding performance (Blaschke et al., 2014). Therefore, it makes sense to consider these activities as a single unit, even though they have their distinct areas of concern.

One way that leadership has been found to influence innovation ecosystems is through establishing a vision. At the most basic level, this would include a vision of the university as an innovation ecosystem, as expressed within the so-called third mission of innovation (Loi and Di Guardo, 2015). Vision also includes the establishment of strategies to achieve the vision, for example establishment of an innovation strategy and appropriate partnerships (Leih and Teece, 2016). An example of this effect is found in a case study on repositioning of land grant universities in the United States (Lyons et al., 2017). As these authors argued, the role of leadership in establishing a new vision for the university was a key aspect of this repositioning. A study in Indonesia argued that setting the mission and vision of the university was one of the core responsibilities of the university leadership, and that establishing effective vision for innovation was a foundational part of success in the university's innovation ecosystem (Mudde et al., 2017). However, they also found that without further communication and leadership practices, the vision had a limited effect on its own in terms of achieving innovation. Another case study showed that the entrepreneurial vision had to be connected to the university's everyday processes and work to be effective (Coyle, 2014). Case studies at European universities showed that the entrepreneurial vision of the university is often weakly stated, without hard or specific targets or activities (Guerrero et al., 2014). Thus, even though this area is critically important, it may be an area that frequently fails.

Another effect of leadership on university innovation ecosystems is through setting and enforcing policies. As Coyle (2014) pointed out, policies need to be designed to remove barriers to innovation as well as provide facilitating resources, not simply to mandate a vague practice of innovation. Policy-making also needs to create a clear divide between the prior position of the university and its new position. As Lyons et al. (2017) explained, land grant universities (their case study) were hemmed in by historic policies that limited their activities and growth. University leadership could change policies to eliminate this historical limitation. A study in Polish universities indicated that university policies, for example promotion of entrepreneurship classes and other activities such as lectures and workshops within the university curriculum, were viewed as a factor in the university's development of an entrepreneurship ecosystem (Sęk, 2017). A study of Work-Integrated Learning (WIL) showed that establishing appropriate policies and the systems required to support and monitor these policies were critical for their success (Rampersad, 2015). However, even with such policies, the actual practices associated with the WIL program were not always conducive to successful performance of the innovation ecosystem. Another type of critical policy is the staffing policy; as a study in Indonesia showed, if staffing is inadequate, professors spend most of their time teaching and little time involved in innovation and research (Mudde, Widhiani and Fauzi, 2017). On the other hand, university policies relating to Intellectual Property (IP) can be established that are highly effective (Guerrero et al., 2014).

University governance has also been associated with the success of the university innovation ecosystem. Governance includes both oversight of the university and integration and coordination of the university's activities with other partners (Mudde et al., 2017). Primarily, it is concerned with the university's structure and how it contributes to innovation (Leih and Teece, 2016). Frequently, this can include the establishment of specific governance bodies designed to provide oversight and policymaking (Guerrero et al., 2014; Lyons et al., 2017), or the establishment of structures. Governance of the Polish university has also been shown to be a factor in the degree to which the entrepreneurship ecosystem influences innovation outcomes (Sęk, 2017). Governance practices ensure that the resources dedicated to the development of the innovation ecosystem are used effectively and that the intended goals are achieved (Rampersad, 2015).

In summary, there are three clear roles for the university leadership in the establishment of an effective innovation ecosystem: 1) Setting a vision, 2) Establishing policies, and 3) Providing governance to ensure outcomes are achieved. Thus, leadership and governance are success factors in university innovation ecosystems.

2.2.2 Educators

While university leaders establish strategies and policies for the innovation ecosystem, it is the educators of the university who are tasked with actually creating the entrepreneurial learning environment (Coyle, 2014). Two areas where educators play the leading role is in curriculum design and implementation, and student outcomes. These areas are related, in that the curriculum design and implementation is what leads to the student outcomes, such as entrepreneurial orientation, entrepreneurial intention, and eventually entrepreneurship and innovation (Morris et al., 2017; Morris et al., 2013).

The first role of the educator is in curriculum design and implementation for entrepreneurship. Development and delivery of an entrepreneurial and innovation curriculum that is up-to-date, relevant and designed with insight from specialists and industry participants, is considered a best practice for the entrepreneurial university (Fernández-Nogueira et al., 2018), as it creates a learning team with multiple competencies (Rae et al., 2009). This type of connection can include, for example, university linkages, or connections between universities and industry (as well as other bodies) (Plewa et al., 2013). University-industry linkages enable enhancements to the curriculum such as, internships and work-integrated learning programs, which help students gain real-world experience in innovation and entrepreneurship (Rampersad, 2015; Fernández-Nogueira et al., 2018). Furthermore, entrepreneurial and innovation curricula should not be limited, but instead should be incorporated throughout the university curriculum side by side with the subject learning (such as biotechnology) (Meyers and Pruthi, 2011). This is contrary to the curricula of many universities, which sometimes offer entrepreneurship education as a specific minor or sub-specialty within business degrees, but do not address entrepreneurship and innovation practices in other educational aspects (Morris et al., 2013).

The other role of educators is the development of measurement strategies for student outcomes that are relevant to the subject matter (Meyers and Pruthi, 2011). These evaluations are not always based on specific knowledge, but may also include factors like entrepreneurial intentions and entrepreneurial orientation (Meyers and Pruthi, 2011). Student outcomes are dependent on both curriculum implementation and communication regarding this curriculum (Coyle et al., 2013). This can have negative consequences; for example, despite an established entrepreneurial education program, a study at a Polish university showed that only a third of students had even heard of academic entrepreneurship, and most had not participated in the entrepreneurial education program (Sęk, 2017). However, it can also have positive consequences; for example, curricula that encourage and develop entrepreneurial orientation can help improve student outcomes like positive attitudes toward entrepreneurship, entrepreneurship knowledge, and entrepreneurial intentions (Koe, 2016). Ultimately, the curriculum and overall student involvement in entrepreneurship activities at university is related to their post-university innovation and entrepreneurship activities (Morris et al., 2017). Thus, the role of educators is not just to facilitate innovation and entrepreneurship learning through curriculum design and instruction, but to encourage the long-term development of entrepreneurship and innovation. Overall, however, there is much less evidence on the outcomes of entrepreneurial and innovation education in the university ecosystem than on process questions such as curriculum design and implementation.

There are some gaps in the understanding of the role of the educator in the curriculum outcomes for entrepreneurial education (Perkmann et al., 2013). In particular, it is possible that there is an interaction between education and innovative activity, given that the same faculty is responsible for both teaching and research; thus, with limited time available, it is possible that increased time spent in curriculum design and implementation reduces the effectiveness of the faculty in innovation (Perkmann et al., 2013). However, this interaction has not been studied at length. Another issue is that educators themselves need support such as training in innovation and entrepreneurial education, especially when the entire university is involved in this effort (Fernández-Nogueira et al., 2018). Thus, in addition to the interaction with innovators, there may also be interactions with leadership.

In summary, there is strong evidence that the university educators play two key roles in the establishment of the innovation ecosystem. First, they are responsible for entrepreneurial education curriculum design and development. Second, they are associated with student outcomes such as entrepreneurial intent. These outcomes are associated with innovators and leaders, due to potential interactions with policies and role conflict of professors as educators and researchers.

2.2.3 Innovators

University professors have a dual role as both educators (those responsible for curriculum development and implementation) and innovators (those responsible for the entrepreneurial activities of the university) (Coyle et al., 2013). The role of innovators is evident in areas including intellectual property (IP) development and commercialization, research funding, and researcher training.

Innovators in the university work directly in innovation, including development and commercialization of IP), for example patents (Coyle et al., 2013). The traditional approach to innovation and technology transfer has *not* been a commercialization model; instead, researchers have developed IP and then transferred responsibility to technology transfer offices to determine whether to patent it (Bradley et al., 2013). Researchers have also traditionally left commercialization to firms, instead licensing raw IP (Bradley et al., 2013). However, there are now new models of commercialization that may be used. For example, innovators may partner directly with firms, creating university-industry linkages (Plewa et al., 2013; De Jager et al., 2017). These linkages or relationships are used to commercialize the innovations created by the researchers during the research process. Another common approach is establishment of spin-off companies, which are commercial entities which exist to commercialize the IP and innovations created during the innovation process (Harrison and Leitsch, 2010; D'Este and Perkmann, 2011). These firms may be established for example to maintain control of the innovation, or to increase the revenue flows for the university or innovators from the invention, even though many are undertaken in cooperation with commercial firms (Lubik et al., 2013). In some cases, proof of concept centers may be established to develop and test commercialization processes prior to licensing, direct commercialization through spin-offs, or technology transfer (Maia and Claro, 2013). In some cases, innovations are developed and then transferred (a process known as technology transfer) for social benefit, rather than being commercialized (Plewa et al., 2013; Payumo et al., 2014; Krumm, 2016). For example, such innovations may be released to the public to facilitate economic development or support small firms (Payumo et al., 2014; De Jager et al., 2017). However, technology transfer from universities is not always effective, and should not be considered the main goal of the innovator (Krumm, 2016).

University staff as innovators are also responsible for securing funding for their research (Coyle et al., 2013). Typically, funding for innovation within the university can come directly from the university or from outside sources such as, governments, institutions and agencies, and firms (Morris et al., 2017). This funding may be solicited directly by researchers, as has historically been the case (Etzkowitz, 2003), or may be centralized through a university office (De Jager et al., 2017). Many research activities are funded through a combination of public and private funding, which can be problematic because it blurs lines between public and private benefits of the research (Celuch et al., 2017). In many cases, however, this must be overlooked because firms are crucial sources of research funding.

Finally, there is the role of the innovator in training the next generation of academic researchers and innovators, which includes the processes of laboratory or research group training (Bronstein and Reihlen, 2014). Student experience with pre-entrepreneurial activities, for example, work in a research laboratory, and is associated with outcomes including post-graduation entrepreneurial activity (Koe, 2016; Morris et al., 2017). Therefore, involving students in innovation training and research is crucial for future outcomes. Another important aspect of training is the training provided to early career researchers, who accept lower pay and limited-time contracts in exchange for a psychological contract which in part includes extended training in research and opportunities to innovate (Lam and de Campos, 2015). Thus, the extent to which the university succeeds in effective training for its students and early career researchers could have a long-term effect on its entrepreneurial outcomes, including those of both students and staff.

In summary, university professors and researchers play a dual role as both educators and innovators. In their role as innovators, they are directly responsible for IP development and commercialization, as well as coordination of research funding and researcher training.

2.2.4 Connectors

Both individuals and groups within the entrepreneurial university may establish, develop and maintain relationships with a range of private and public partners for innovation (OECD, 2012). In this research, this role is termed the connector role. Interaction between the university, industry, and government is the basis for the so-called triple helix model of university innovation (Jarábková et al., 2019). Entrepreneurial universities are built on underlying relationships between both members of the organization and across organizational boundaries with members of other organizations (Guerrero and Urbano, 2012). The innovation network perspective (Greenacre et al., 2012; Ahrweiler and Keane, 2013; Acemoglu et al., 2016) is a useful theoretical model to understand the importance of relationship building, as it emphasizes the role of relationship networks between individuals as part of the innovation process. While the connectors component also addresses relationships, the relationships investigated here are informal relationships that are not based on formal agreements between universities and other organizations, but on informal collaborations between members of the university organization and other organizations.

The first type of relationship that is relevant to the entrepreneurial university is internal relationships between administrators, staff, and students within the organization. Researchers within the university, including students, staff members (both faculty and researchers), build relationships with each other during the process of research into shared interests (Hayter, 2016). These relationships help offset the homophily of researchers' and students' own social networks and draw in a wider set of acquaintances that can be drawn upon. Student-faculty relationships outside the innovation arena are also an important aspect of the entrepreneurial university (Jones and Andrews, 2019). For example, Faculty-Student Coaching (FSC) programs aim to create enduring one-on-one relationships between students and faculty members, which can include research relationships (Jones and Andrews, 2019). These types of relationships clearly exist within the informal environment of the entrepreneurial university model (Kirby et al., 2011; Guerrero and Urbano, 2012). However, they are not always studied in great detail.

The second type of relationship that is relevant is ones that cross organizational boundaries, either with other universities or government and industry organizations. These types of relationships can occur at the trustee level of the university, as shown by a study of the Association of American Universities trustees (Barringer and Slaughter, 2016). Trustees may have relationships with several different organizations, including other universities, private corporations and government, which they can leverage to assist in development of entrepreneurial universities (Barringer and Slaughter, 2016). There are also cross-organizational relationships between individual researchers and research groups, as evidenced by investigations that have focused on analysis of patent filings (Ahrweiler and Keane, 2013; Leydesdorff and Ahrweiler, 2014; Acemoglu et al., 2016) and co-citations of academic research papers (Tijssen et al., 2016). Cross-university research relationships began to develop even before the entrepreneurial university, due to falling costs of communication with the advent of the

Internet (Agrawal and Goldfarb, 2008). University-industry research relationships have also been commonplace for some time, but have accelerated due to the repositioning of the university as an innovation ecosystem (Tijssen et al., 2016).

The effect of relationship building within the university is somewhat controversial. It has been shown that such relationships are critical to innovation. For example, developing new social network ties through the relationships of others is one of the ways in which university spinoffs become successful (Hayter, 2016). At the same time, too great an emphasis on innovation as it applies to students and early career researchers can be harmful (Lam and de Campos, 2015; Herrmann, 2017). For early career researchers, a highly competitive environment can damage relationships with senior colleagues and discourage collaboration (Lam and de Campos, 2015). For students, highly competitive and innovation-focused environments can be beneficial for if they are competitive, but for non-competitive students, or those who are not focused on innovation, the emphasis on innovation relationships can damage their overall experience and their faculty relationships (Herrmann, 2017). Thus, as with agents of change, relationship builders need to be monitored to ensure that they are building the right kind of relationships – ones that support, rather than detract from, innovation.

Relationships with private partners, including industry and firms, are one of the most visible types of connector activities in the literature. These relationships can take many forms, which serve to "generate an umbrella for interaction, collaboration and co-operation (Guerrero et al., 2014)." While technology transfer units or similar approaches are commonplace as a route to firms (Kivimaa et al., 2017), more intensive relationships have also become common. For example, one study showed that the entrepreneurial university played a role as a regional innovation ecosystem integrator, with private firms offering training partnerships for students and the university offering innovation assistance and support (Celuch et al., 2017). In a case in Portugal, a Proof of Concept Centre was established to work with private partners to test innovation ideas and develop innovation strategies (Maia and Claro, 2013). Another study in the UBC ecosystem found that firm partnerships were critical not just for innovation, but also for curriculum design and implementation (Galan-Muros and Davey, 2019). Firms may offer internships and work experience for students, as well as priority hiring programs for graduates (Jarábková et al., 2019). Industry partners may also support university innovation through other means, such as supporting scholarships, prizes, and non-curriculum learning opportunities like workshops for students (Guerrero et al., 2014). A study based in the UK identified a much wider set of connection activities with private firms, including contract research, consulting, and collaborative research (Perkmann et al., 2011). These relationships between individual faculty and private partners may be conducted outside the formal structure of the entrepreneurial university, but are still part of the innovation processes of the university (Perkmann et al., 2011). It is important to keep in mind that these partnerships are evolving over time as the idea of the entrepreneurial university is developing (McConnell and Cross, 2019). Whereas previously, such relationships were likely to be one-time partnerships, it is increasingly common for universities and industry to develop long-term relationships and for university resources to be integrated into firm innovation (McConnell and Cross, 2019). Thus, relationships with private partners can serve multiple purpose within the university and the firm and can range from one-off arrangements to sustained relationships.

As with university-private partnerships, university-public institution partnership can take a variety of forms and serve multiple innovation purposes as part of the community innovation ecosystem (Morris et al., 2017). To some extent, government or institutional partners may be more remote than private partners; for example, government policies on innovation and educational support shape the broader context of the entrepreneurial university, including its social mandate and its overall financial support (Galan-Muros and Davey, 2019).

However, governments may also provide direct support for innovation programs. For example, in one case, a university developed a program to assist in access to fresh food for people receiving nutrition support through SNAP/WIC programs (Celuch et al., 2017). In the case of the University of Coimbra (Portugal), it was found that university-public institution partnerships, rather than university-private partnerships, prevailed due to a history of extensive support for technology commercialization by the Portuguese government (Maia and Claro, 2013). Government programs are also part of the funding structure for research and, at least in the UK, has been found to outweigh the contribution share of grants from private industry (Perkmann et al., 2011). This is also true of universities in Spain (Guerrero et al., 2014). In Thailand, government partners play a significant role in university innovation, although they also impose costs related to regulation and compliance, which can make government partners more difficult to work with than private partners (Koiwanit et al., 2019). Thus, university partnerships with government includes both macro-scale government policy-making and funding, and micro-scale cooperation projects.

In summary, the connectors of the university's innovation ecosystem include internal and external relationships with both public and private partners. The role of university community members as relationship builders, both within the university's organizational boundaries and outside it, is another aspect of the entrepreneurial university. However, these relationships, as part of the informal environment of the university, have only rarely been studied explicitly. In part, this is because of a problem formulating metrics that capture relationship building, as standard techniques like SNA and co-citation analysis do not capture the full complexity of such relationships (Leydesdorff and Ahrweiler, 2014; Tijssen et al., 2016).

2.2.5 Agents of Change

A fifth role within the entrepreneurial university is the agents of change. Change is systemic in the implementation of entrepreneurial universities, as it typically requires a shift in organizational vision and mission, as well as policies and internal structures (Sęk, 2017). Change is not a one-time occurrence, but is an ongoing process as the idea of the entrepreneurial university itself emerges (McConnell and Cross, 2019). Furthermore, change happens continuously within the entrepreneurial university as it responds to changes in the external environment (Guerrero and Urbano, 2012). Management of change throughout the other elements of the framework, from leadership to relationship building, is a key process that universities need to ensure in order to implement and sustain innovation (Koiwanit et al., 2019). A change agent is an actor within the university's innovation ecosystem, or adjacent to this ecosystem, that provides the impetus for change to occur (Brennan et al., 2014).

One of the implications of the systemic nature of change and change management within the university's innovation ecosystem is that many community members can become agents of change. Typically, change may occur through the actions of leadership and manager, who direct and implement change at the university level (Galan-Muros and Davey, 2019). These leaders are responsible not just for formal changes in policy and direction, but for the change in culture that is required to develop a university innovation ecosystem (Ortiz-Medina et al., 2016). It is also common that faculty members, including both teaching staff and research staff, act as agents of change (Ortiz-Medina et al., 2016; Wakkee et al., 2019). As teaching staff, faculty members design and implement curricula, including that which specifically addresses innovation and entrepreneurship (for example courses and minors in the topic) and inclusion of innovation and entrepreneurship in other areas of the curriculum (Ortiz-Medina et al., 2016). As research staff, faculty members engage in innovation and entrepreneurial activities, but they also direct the course of the university's innovation programs (Wakkee et al., 2019). For example, Wakkee, et al. (2019) showed that entrepreneurial researchers and students played a key role in sustainability policy for the university, with their concern over economic and social sustainability in the local community informing the development of a sustainability vision. There is even evidence that students can act as change agents, as they respond to changing demands from employment markets by promoting change in curricula and policies (Hongjuan, 2018). Students may also engage in innovation research on their own, offering some control over the direction of innovation at the university (Wakkee et al., 2019). However, the ability to become a change agent is not universal. For example, one study on non-tenure track faculty showed that they were reluctant to act as agents of change because of their perception that they had limited ability to enact the changes they saw as beneficial (Drake et al., 2019). Thus, although in theory any member of the university community could become a change agent, in practice this may be much more limited.

There is a need for change mechanisms and change management to be used, in order to make sure that the change occurs in a way that is beneficial and that resistance to change can be overcome (Galan-Muros and Davey, 2019). It may also be necessary to manage change in order to increase the rate of change, which is in many cases very slow due to entrenched interests and assumptions about the role of the university (Hongjuan, 2018). Change management also needs to deal with the fact that sometimes changes do not always have the desired or expected outcomes (Kolympiris and Klein, 2017). For example, Kolympiris and Klein (2017) investigated the establishment of an academic incubator, which is a less formal approach to innovation than the traditional approach of the technology transfer office. They showed that academic incubators had a negative effect on the quality of innovation due to resource shortages and conflicts, as well as lower standards (Kolympiris and Klein, 2017). Thus, change management includes not just planning and implementing change, but also monitoring change to ensure that the desired effects are observed.

In summary, agents of change are those that promote, implement and manage change within the university. These change agents can come from all levels of the university, but not all community members have equal power to effect change.

2.3 Performance Measurement in Higher Education

Since the objectives of this research revolve around developing a performance measurement approach for the university, it is worth looking at how performance measurement systems are currently implemented in higher education and what issues there are surrounding it. Up to the 1980s, most universities were oriented toward teaching and learning as their main missions, and performance measurement systems therefore focused on learning outcomes like research and scholarship, cultural and social contributions, and quality of graduates (Higgins, 1989). Beginning in the 1980s and 1990s, however, universities began to adopt a goal-directed approach to performance measurement, using quantitative measures that were assumed to be objective (Modell, 2003). In practice, of course, these quantitative measures were also based on assumptions about the nature of the university and were driven by institutional pressures that increased emphasis on quantification of university outputs (Modell, 2003). However, to date, university performance measurement strategies are still in flux, and no single model or set of criteria has emerged (Grossi et al., 2020). As these authors note, the diversity of institutional pressures, particularly variance in state pressures and regulatory control, means that universities have not arrived at a single solution. However, there are some approaches that are more common than others.

One approach that is in use today at some (though not all) universities can be described as ‘management by results’, in which academic and researcher outcomes are the focus of quantitative performance measures (Kallio and Kallio, 2014). For example, this approach may focus on the quantitative numbers for research, such as the number of papers published, impact factors and journal rankings, and other measures for individual academics, while for departments and universities as a whole the focus may be on cross-university rankings. Kallio and Kallio (2014) note that this creates conflict within the university, particularly where creative work and novel work is being conducted, and that it has negative effects on the work motivation and performance of academics. Another author has noted that such an approach, which focuses on external measures, is often used symbolically rather than rationally, in effect to legitimize the university as a serious research organization (Dobija et al., 2019). Thus, such a performance measurement approach can support the external goals of the university, but may not be relevant to internal performance. In fact, this external ceremonial use of performance measurement is often only loosely linked, if at all, with internal, rational uses of performance measurement to address the university's systems and processes and identify opportunities for change (Dobija et al., 2019).

In practice, many universities use only a limited performance measurement approach, which may be more oriented to external reporting requirements than internal process or outcome improvement (Alach, 2017). Alach (2017), whose work investigated performance measurement in New Zealand universities, showed that while outcome-based performance measurement frameworks are well-aligned to university strategies, the actual breadth of measures, consistency and quality of their application, and connection of performance measures to university decisions, is far less consistent. He argued that a combination of lack of accountability and internal organizational culture results in performance measurement systems being only loosely linked with internal performance goals (Alach, 2017). A further issue with the performance measurement approach used in universities is that it is not well understood by innovation partners (Rantala and Ukko, 2018). Innovation partners such as SMEs respond positively to the quantitative performance measures produced by universities, but may not really understand the internal process by which these measures are produced, or their fundamentally external-facing and symbolic nature (Rantala and

Ukko, 2018). Therefore, such measures have the potential to miscommunicate to university innovation partners.

2.4 Conceptual Framework

The conceptual framework is developed based on several previous models of the university ecosystem and its development, including the entrepreneurial university development model proposed by Kirby, et al. (2011) and its extension by Guerrero and Urbano (2012), the OECD's (2012) entrepreneurial university framework, and the Thailand National Science, Technology and Innovation Policy Office's (2018) entrepreneurial university model. However, this research does not draw solely on any of these models. Instead, it is an integrated model, which seeks to fill gaps in the existing models by carefully combining different elements.

As Table 2 shows, these frameworks have a lot of elements in common. This table is arranged along the stakeholder orientation of the entrepreneurial university model (Thailand National Science, Technology and Innovation Policy Office, 2018). The stakeholders that play a role in the entrepreneurial university include leaders and governors, educators, innovators, connectors, and agents of change. The different elements of each of these frameworks can be assigned to at least one of these stakeholder perspectives, making it a comprehensive model that can be investigated carefully.

Comparison of these models shows that some are more complete than others. The OECD (2012) model is by far the sparsest, with a focus on elements on connectors and change agents, but relatively little emphasis on educators and innovators and even less investigation of leaders and governors. Thus, even though as previously remarked, the OECD (2012) model is uniquely useful because of its operationalized nature, it has limited coverage. The coverage of the Kirby et al. (2011) model is somewhat better, especially for educators and innovators, and the Guerrero and Urbano (2012) model extends this further. However, these two models are still relatively weak, especially in commercialization aspects like business development and innovation development. Thus, there is a clear case for extending these models to incorporate additional measures that address the key process of commercialization and innovation development, which should not be left to the private sector.

The entrepreneurial university model (Thailand National Science, Technology and Innovation Policy Office, 2018) is the most comprehensive of the models, incorporating the majority of the elements of the other models. However, it is missing some key aspects of innovation and especially commercialization, including market research (which is not actually incorporated into any of the frameworks used) and knowledge management (Kirby et al., 2011; Gurrero and Urbano, 2012; OECD, 2012). Since these aspects of the innovation process are crucial for commercialization, they are included in the current framework. The inclusion of market research activities is a new contribution, as it focuses the performance measurement model more firmly on the commercialization of market-relevant innovation, which is an area where Asian universities have been shown to lag compared to leading universities in other countries (Fisch et al., 2015; Singh et al., 2015). The inclusion of knowledge management is done because, based on the assessment of earlier models, knowledge management is part of the university's strategic toolset for developing a sustained innovation ecosystem (Kirby et al., 2011; Gurrero and Urbano, 2012). Thus, even though it is not an explicit part of the entrepreneurial university model (Thailand National Science, Technology and Innovation Policy Office, 2018), it is still well worth including and extending the conceptual framework of the previous study.

As previously noted, there are already multiple competitiveness ranking systems in place. These ranking systems may incorporate innovation as an aspect in a university ranking system, such as the (2019) World University Ranking Systems. Alternatively, they may incorporate universities and their contribution to the national innovation ecosystem as part of a national competitiveness ranking, as in the cases of the IMD World Competitiveness rankings (IMD, 2019), Notre Dame Global Adaptation Initiative (ND-GAIN) Country Index of climate readiness (ND-GAIN, 2019), or the World Economic Forum's (WEF) Global Competitiveness Index (Schwab, 2019). The availability of these ranking systems raises the question of how the proposed performance evaluation system will contribute and whether the system developed could be used as the basis for a more comprehensive evaluation of university innovation ecosystems within the context of these models.

The proposed conceptual framework is intended to evaluate innovation ecosystems at the university level, and therefore would not be an appropriate substitution for the ranking systems used in the country-level evaluations generally. However, it is possible that the proposed conceptual framework and the evaluation tools developed from it could be deployed to provide a more comprehensive understanding of the university's innovation ecosystem and its role in the national innovation ecosystem. For example, if evaluated at the university level, it could provide a more comprehensive evaluation of innovation than the THE's (2019) framework, which is based primarily on patent registrations and research activity, rather than a broader perspective that incorporates aspects like leadership and innovation culture. At the national level, if universities were each assessed this could provide more detailed information for the role of universities in the innovation ecosystem. Since these indices typically use relatively simple measures of university contributions, such as research funds it could also be useful in this aspect, although it would need to be used at the national level to provide a comparable result.

Table 2 Comparison of key theoretical models contributing to the conceptual framework

Dimensions	Components	Kirby, et al., (2011)	Guerrero and Urbano (2012)	OECD (2012)	Thailand National Science Technology and Innovation Policy Office (2018)	This present study
Leaders and Governors	Leadership and governance	✓	✓		✓	✓
	Strategy development (policy and strategy)				✓	✓
	Culture	✓	✓	✓	✓	✓
	Measurement management				✓	✓
	Resource management		✓	✓	✓	✓
	Infrastructure	✓	✓	✓	✓	✓
Educators	Curriculum	✓	✓		✓	✓
	Business/ learning outcome	✓	✓	✓	✓	✓
Innovators	Commercializing innovation	✓	✓		✓	✓
	Financial management	✓	✓		✓	✓
	Human resource focus	✓	✓	✓	✓	✓
	Incentive and reward system			✓	✓	✓
	Traning/Mentors/ coaching		✓		✓	✓
	Role model	✓	✓		✓	✓
	Business development				✓	✓
	Market research					✓
	Innovation development		✓		✓	✓
Connectors	Partnership/ engaing with stakeholders	✓	✓	✓	✓	✓
	Knowledge management	✓	✓	✓		✓
	Entrepreneurship education/ pathways	✓	✓	✓	✓	✓
	Entrepreneurship hub/ center/ communty	✓	✓	✓	✓	✓
Agents of Change	Communication/ change management	✓	✓	✓	✓	✓
	Attitude (stakeholders)	✓	✓		✓	✓

As discussed in Section 1.2 and 2.1.5, none of the models of the university as an innovation environment are completely satisfactory for development of a measurement model. Therefore, the empirical evidence (summarized in Section 2.2), particularly Thailand's National Science Technology and Innovation Policy Office (2019)'s entrepreneur model was drawn on to identify the dimensions of the entrepreneurial university in a way that could be measured. This empirical evidence was used to develop the dimension and components of conceptual framework for the paper.

A role-based approach was chosen for the conceptual framework. This role-based approach was chosen in acknowledgement that many members of the university organization play more than a single role in the establishment of the university's innovation ecosystem. For example, leaders and governors set the vision and policies of the organization, but they also play a role in creating change in organizational culture. The five roles that are identified within the conceptual framework include:

Leaders and Governors: Activities including, setting the vision and mission of the organization, establishing policies, and providing governance and oversight, as well as resource and infrastructure.

Educators: Activities including, designing and implementing curricula and other academic learning opportunities, and ensuring student outcomes.

Innovators: Activities including, development and commercialization of innovations, securing funding, training researchers.

Connectors: Activities including, developing and maintaining social and research relationships (networking and collaboration) between members of the organization and across organizational borders.

Agents of Change: Activities including, promoting, communicating implementing, and managing change within the university.

The hypotheses of the study are developed from the assessment of the literature, including studies on innovation and the innovation ecosystem within the university. They draw from a range of existing models, including those proposed by Guerrero and Urbano (2012, 2014), the OECD (2012) and the National Science Technology and Innovation Policy Office (2019). These studies identified central elements of the university innovation ecosystem, including the university's leadership and governance, its teaching and curriculum policies and practices, its research policies and practices, its connections with other universities and researchers, and its readiness and capability for change. Not every model identified every one of these aspects of the innovation ecosystem. However, they all had empirical support from case studies and other empirical research into university innovation ecosystems. Therefore, there were five hypotheses proposed for the study, which encapsulate these anticipated relationships.

The hypotheses of the study are as follows:

Hypothesis 1: Activities of Leaders and Governors influence the university innovation ecosystem.

Hypothesis 2: Activities of Educators influence the university innovation ecosystem.

Hypothesis 3: Activities of Innovators influence the university innovation ecosystem.

Hypothesis 4: Activities of Connectors influence the university innovation ecosystem.

Hypothesis 5: Activities of Agents of Change influence the university innovation ecosystem.

Figure 9 is a representation of the conceptual framework, including its primary concept (the university innovation ecosystem), its central dimensions (Leaders and Governors (L), Educators (E), Innovators (I), Educators (E), Connectors (C), and Agents of Change (A)), and the sub-dimensions that make up the primary dimensions. The conceptual framework also shows the expected relationships between the primary dimensions and the university innovation ecosystem, which is the central dimension of the paper, and which are the basis for the hypotheses discussed above.

The conceptual framework acts as a guidance tool for the mixed methods research for this study. The approach to the research design is explained in more detail in the following chapter. The remainder of this chapter summarizes the evidence for the proposed relationships and the operationalized definitions for the variables of interest, both of which come from the theoretical and empirical literature.

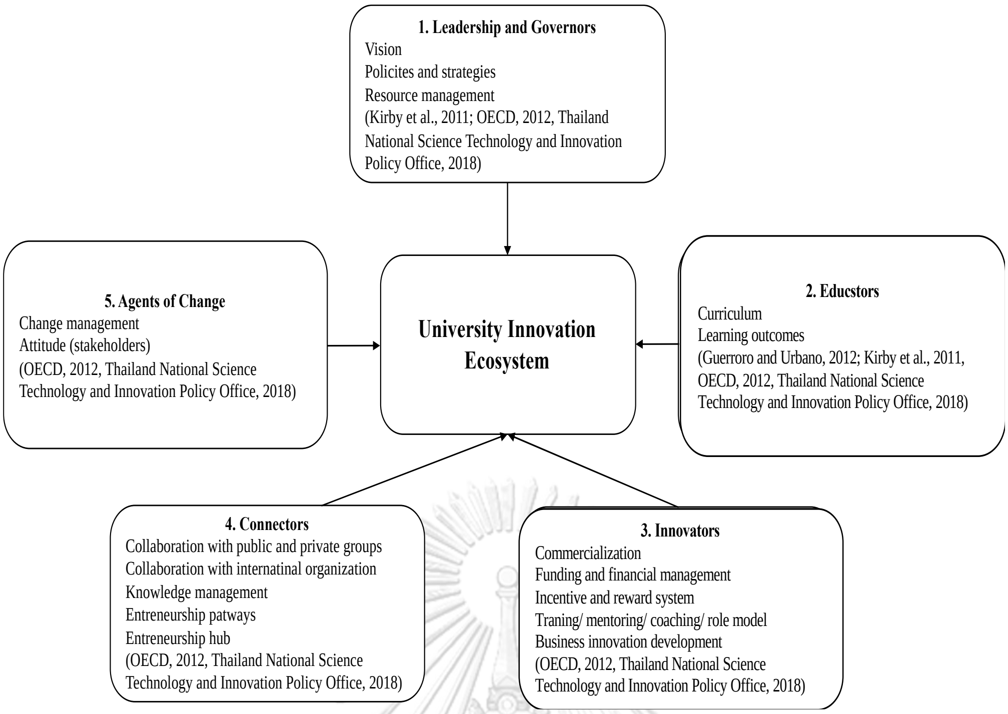


Figure 9 The conceptual framework of this research

Table 3 provides a summary of the evidence for the conceptual framework, made up of the studies that were reviewed within the literature review. These studies include a mixture of theoretical and empirical works. Central sources for the dimensions include the innovation ecosystem frameworks developed by earlier authors (Kirby et al., 2011; Guerrero and Urbano, 2012; OECD, 2012; Coyle, Gibb and Haskins, 2013; Guerrero et al., 2014; HEInnovate, 2014; National Science Technology and Innovation Policy Office, 2018). There were also many sources that addressed only a few dimensions of the conceptual framework, rather than being widely representative. As will be explained in the methodology in the next chapter, these sources provided both empirical support for definitions and components and were used in the formulation of the initial framework for the Delphi study.

Table 3 Summary of the evidence for the conceptual framework

Dimension	Component	Authors
Leaders and Governors	Vision	Babson (2016) Coyle (2014) Guerrero and Urbano (2012) Guerrero et al. (2014) Kirby et al. (2011) Leih and Teece (2016) Lyons et al. (2017) Mudde et al. (2017) National Science, Technology and Innovation Policy Office (Thailand) (2018)

Dimension	Component	Authors
	Policies and strategies	EULP (2014) Guerrero et al. (2014) Lyons et al. (2017) Mudde et al. (2017) National Science, Technology and Innovation Policy Office (Thailand) (2018) Rampersad (2015) Sęk (2017)
	Governance	Coyle (2014) Guerrero et al. (2014) Guerrero and Urbano (2012) HEInnovation (2014) Kirby et al., (2011) Leih and Teece (2016) Lyons, et al. (2017) MBNQA (2015) Mudde, et al. (2017) Rampersad (2015) Sęk (2017)

Dimension	Component	Authors
	Resource management	Babson (2016) Guerrero and Urbano (2012) HEInnovation (2014) National Science, Technology and Innovation Policy Office (Thailand) (2018) OECD (2012)

Dimension	Component	Authors
Educators	Curriculum	Coyle (2014) Fernández-Goguerira et al. (2018) Guerrero and Urbano (2012) Kirby et al. (2011) MBNQA (2015) Meyers and Pruthi (2011) Morris, et al. (2013) Morris, et al. (2017) National Science, Technology and Innovation Policy Office (Thailand) (2018) Perkmann, et al. (2013) Plewa et al. (2013) Rae et al. (2009) Rampersad (2015)

Dimension	Component	Authors
	Learning outcomes	Coyle et al. (2013) Guerrero and Urbano (2012) Kirby et al. (2011) Koe (2016) Meyers and Pruthi (2011) Morris et al. (2017) National Science, Technology and Innovation Policy Office (Thailand) (2018) OECD (2012) Sęk (2017)

Dimension	Component	Authors
Innovators	Commercialization	Bradley et al. (2013) Coyle et al. (2013) D’este and Perkmann (2011) De Jager et al. (2017) Guerrero and Urbano (2012) Harrison and Leitsch (2010) Kirby et al. (2011) Krumm (2016) Lubik et al. (2013) Maia and Claro (2013) National Science, Technology and Innovation Policy Office (Thailand) (2018) Payumo et al. (2014) Plewa et al. (2013)

Dimension	Component	Authors
	Funding and financial management	Celuch et al. (2017) Coyle et al. (2013) De Jager et al. (2017) Etzkowitz (2003) Guerrero and Urbano (2012) Kirby et al. (2011) Morris et al. (2017) National Science, Technology and Innovation Policy Office (Thailand) (2018)
	Incentive and reward system	Clark (1998) Guerrero and Urbano (2012) Kirby et al (2011) HEinnovation (2014) National Science, Technology and Innovation Policy Office (Thailand) (2018) OECD (2012)

Dimension	Component	Authors
	Training/mentoring/coaching	Bronstein and Reihlen (2014) Guerrero and Urbano (2012) Koe (2016) Lam and de Campos (2015) Morris et al. (2017) National Science, Technology and Innovation Policy Office (Thailand) (2018)
	Role model	HEInnovation (2014) Guerrero and Urbano (2012) Kirby et al (2011) National Science, Technology and Innovation Policy Office (Thailand) (2018)
	Business/innovation development	Babson (2016) Guerrero and Urbano (2012) Ireland (2014) National Science, Technology and Innovation Policy Office (Thailand) (2018)

Dimension	Component	Authors
Connectors	Collaboration with public and private groups	Acemoglu et al. (2016) Agrawal and Goldfarb (2008) Ahrweiler and Keane (2013) Barringer and Slaughter (2016) Celuch, et al. (2017) Galan-Muros and Davey (2019) Guerrero and Urbano (2012) Guerrero et al. (2014) Jarábková et al. (2019) Kivimaa et al. (2017) Kirby et al. (2011) Leydesdorff and Ahrweiler (2014) Maia and Claro (2013) McConnell and Cross (2019) National Science, Technology and Innovation Policy Office (Thailand) (2018) OECD (2012) Perkmann et al. (2011) Tijssen et al. (2016)

Dimension	Component	Authors
	Collaboration with internal organization	Babson (2016) Clark (1998) EULP (2014) Guerrero and Urbano (2012) HEInnovation (2014) Ireland (2014) Kirby et al (2011) Nanyang Technology University (NTU) (n.d.) National Science, Technology and Innovation Policy Office (Thailand) (2018) National University of Singapore (n.d.) OECD (2012)
	Knowledge management	Kirby et al (2011) Guerrero and Urbano (2012) MBNQA (2015) OECD (2012) UNSW Sydney (2016)

Dimension	Component	Authors
	Entrepreneurship education/pathways	Guerrero and Urbano (2012) HEInnovation (2014) Ireland (2014) Kirby et al (2011) Massachusetts Institute of Technology (MIT) National Science, Technology and Innovation Policy Office (Thailand) (2018) National University of Singapore (n.d.) OECD (2012) UNSW Sydney (2016)

Dimension	Component	Authors
	Entrepreneurship hub	Guerrero and Urbano (2012) Ireland (2014) Kirby et al (2011) Massachusetts Institute of Technology (MIT) (n.d.) National Science, Technology and Innovation Policy Office (Thailand) (2018) OECD (2012) Tel Aviv University (TAU) (n.d.)

Dimension	Component	Authors
Agents of Change	Change management/communication	Brennan et al. (2014) Drake et al. (2019) Galan-Muros and Davey (2019) Guerrero and Urbano (2012) Hongjuan (2018) Ireland (2014) Kirby et al. (2011) Koiwanit, et al. (2019) Kolympiris and Klein (2017) McConnell and Cross (2019) National Science, Technology and Innovation Policy Office (Thailand) (2018) OECD (2012) Ortiz-Medina et al. (2016) Sęk (2017) Wakkee et al. (2019)

The final task for this chapter was operationalizing the variables, or in other words, developing working definitions that are used for the primary research (Park et al., 2020). Operationalized variables are summarized in Table 4. The variables are operationalized at the component level; for example, Leaders and Governors does not have a formal operational definition, because it is measured as a latent construct rather than directly (Byrne, 2016). However, the Vision component of the Leaders and Governors does have an operational definition, because it is one of the observed variables (Byrne, 2016). Therefore, there are 18 operationalized variables. Each of these operationalized variables include the component name and the brief operational definition of the component. They also include the measurement items that are addressed within the preliminary scale and the sources for these items. As discussed in the next chapter, the components and measurement items do shift during the courses of the research stages, so these operationalized definitions are not the final definitions of the study, but they do provide a starting point for the research.

Table 4: Operational Definitions of the Study

Dimension	Component	Operational definition	Measurement items	Sources
Leaders and Governors	Vision	The university's vision toward innovation.	State vision of innovation. Vision is clearly communicated in materials and policy.	Thailand National Science, Technology and Innovation Policy Office (2018)

Dimension	Component	Operational definition	Measurement items	Sources
	Policies and strategies	University policies and implementation of strategy to facilitate innovation.	Entrepreneurship is a major part of the university strategy. There is a high-level commitment to implementing the entrepreneurial strategy. There are clear policies on innovation and innovation activities.	Kirby et al. (2011) OECD (2012) Thailand National Science, Technology and Innovation Policy Office (2018)

Dimension	Component	Operational definition	Measurement items	Sources
	Governance	The university's approach to governing innovation and entrepreneurship.	There are governance bodies that address innovation and entrepreneurship. There are university organizations that are tasked with innovation and entrepreneurship. There is a university culture of innovation and entrepreneurship.	

Dimension	Component	Operational definition	Measurement items	Sources
	Resource management	The university's capability to collect and distribute resources to facilitate innovation.	The university has a model for coordinating and integrating entrepreneurial activities at all levels. The university's entrepreneurial objectives are supported by a wide variety of funding sources, including external investment.	OECD (2012)

Dimension	Component	Operational definition	Measurement items	Sources
Educators	Curriculum	The formal and informal entrepreneurial learning opportunities for students.	The university has a comprehensive set of courses on innovation and entrepreneurship. The university offers entrepreneurial learning in non-degree programs like workshops and lectures. The university offers entrepreneurial training programs (e.g., laboratory roles, internships and work experience)	Kirby et al. (2011) Guerrero and Urbano (2012) OECD (2012) Thailand National Science, Technology and Innovation Policy Office (2018)

Dimension	Component	Operational definition	Measurement items	Sources
	Learning outcomes	The extent to which the university promotes student learning on innovation and entrepreneurship.	The university assesses student innovation and entrepreneurship activities.	Thailand National Science, Technology and Innovation Policy Office (2018)
Innovators	Commercialization	The formal commercialization activities of the university.	The university's researchers and faculty are engaged in research and commercialization.	OECD (2012) Thailand National Science,

Dimension	Component	Operational definition	Measurement items	Sources
	Funding and financial management	The funding and financial arrangements for innovation.	Public and private funding is available and sufficient for entrepreneurial activities. Research staff effectively gain funding	Technology and Innovation Policy Office (2018)

Dimension	Component	Operational definition	Measurement items	Sources
	Incentive and reward system	Creation of financial and non-financial incentives for innovation.	There are clear incentives and rewards for staff who support the university's entrepreneurial activities. Status and recognition are offered to staff and other stakeholders who support the university's entrepreneurial activities.	

Dimension	Component	Operational definition	Measurement items	Sources
	Training/mentoring /coaching	The provision of formal and informal training for innovation and development.	Staff are effectively trained for innovation. Students and early career researchers are offered innovation training.	
	Role model	The provision of role models with entrepreneurial experience.	The university has a mentorship program for students and early career researchers and faculty that emphasizes innovation.	
	Business/ innovation development	The university's offering of assistance in innovation and business development.	A business development and innovation development process.	

Dimension	Component	Operational definition	Measurement items	Sources
Connectors	Collaboration with public and private groups	The university's collaboration with different groups to facilitate innovation.	The university has short-term partnerships with public and private agencies for innovation. The university has long-term partnerships with public and private agencies for innovation. The university collaborates with the local community.	

Dimension	Component	Operational definition	Measurement items	Sources
	Collaboration with internal organization	The degree of internal collaboration between stakeholders for innovation.	Administrators, governors, researchers, educators and students form networks for internal collaboration.	Thailand National Science, Technology and Innovation Policy Office (2018)
	Knowledge management	Capture, retention and transformation of knowledge for the university.	Knowledge on innovation is effectively captured and managed.	OECD (2012)
	Entrepreneurship education/pathways	There is a formal entrepreneurial education program in place.	The university has innovation and entrepreneurship development tracks in degree programs at the undergraduate and graduate level, incorporating coursework and practical experience.	Thailand National Science, Technology and Innovation Policy Office (2018)

Dimension	Component	Operational definition	Measurement items	Sources
	Entrepreneurship hub	The university acts as a central hub of innovation.	Researchers, educators, administrators and governors network outside the bounds of the university.	
Agents of Change	Change management	The extent to which students, educators, researchers, leaders, and governors can act as change agents and managers.	Students, educators, researchers, leaders and governors act as agents of change. Students, educators, researchers, leaders and governors act as change managers. Change is actively managed.	

CHAPTER III
RESEARCH METHODS

The previous chapter incorporated a comprehensive literature review that addressed theoretical and empirical backgrounds of the entrepreneurial university, culminating in a preliminary conceptual framework for testing in the primary research. In this chapter, the focus turns to how the primary research was conducted, and what processes were used to develop and refine the measurement model for the research.

The chapter begins with an overview of the research method and explains why mixed methods techniques were chosen. The attention then turns to the research process. The research process is a three-stage process following an exploratory instrument development design. It includes a Delphi study, an expert survey and nomological testing, each of which are explained here. The final section of the chapter reflects on the ethical issues of the study.

3.1 Research Methodology and Design

The research methodology for the study can be described as a qualitative-led mixed-methods study, combining elements of both qualitative and quantitative research (Creswell, 2014). Furthermore, since the eventual outcome was development of a measurement instrument, the appropriate research design was an exploratory instrument development model (Creswell and Plano Clark, 2018). The general form of this design is depicted in Figure 10. This design, known as a qual $\rightarrow$ QUAN exploratory design, begins with data collection and analysis, typically to develop a research instrument or other tool (Creswell and Plano Clark, 2018). The instrument is then tested through application in quantitative research. Interpretation of the findings is driven by the quantitative findings, but informed by qualitative findings. Thus, this design is appropriate for development and initial testing of research instruments and assessment tools, which is the main objective of the current study.

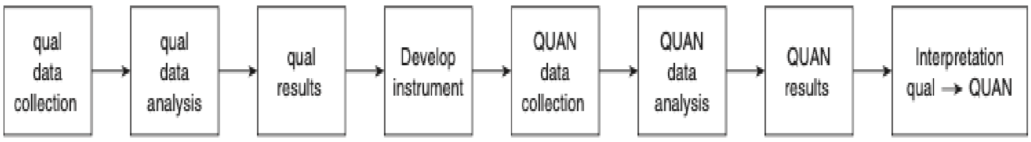


Figure 10 The generalized form of the exploratory research design: instrument development model (Creswell and Plano Clark, 2018, p. 76)

Quantitative research was selected for the study, as the intent was to develop the university innovation model and ensure its statistical reliability and validity, it was essential to use methodologies that could test for causal relationships and structures and that could be replicated by others (Mukherjee, 2020). Thus, the quantitative methodology, which requires stringent standardization and quality control of data collection and analysis to ensure such qualities (Saunders and Lewis, 2017) was the most appropriate choice for much of the study. At the same time, there were some questions that could not be answered adequately through quantitative research, as they required expert insight and information about the topic and the researcher was working initially from a poorly defined theoretical framework (due to lack of earlier development and fragmentation of theories on university innovation ecosystems). Thus, the initial stage of the research was more appropriate for qualitative methods, which allow for deeper investigation and exploration of the research questions (Hennink et al., 2020).

The research design was a three-stage design, incorporating a Delphi study, an expert survey, and a second survey for nomological testing. Each of these techniques were selected to accomplish a specific purpose in the research process, which is described in Figure 11. As this figure shows, the research began with a literature review, which resulted in both a theoretical critique of existing models and an initial framework for testing. The initial framework was brought into Stage 2, which was a Delphi study. The Delphi study, which investigates expert consensus, led to development of a preliminary assessment instrument. In Stage 2, a broader expert survey was then conducted to refine the assessment instrument. The refined instrument was then tested once more in Stage 3, where nomological testing was conducted to test the proposed relationships of the research model. This resulted in the final assessment instrument as measured here. The specific steps to each stage are discussed further below.

Stage 1. The Delphi technique is a small-scale qualitative or mixed-methods research design which is used to establish expert consensus on a particular problem or issue (Hsu and Sandford, 2010), without excessive bias or personal opinion as achieved in smaller expert studies or case studies (Ogbeifun et al., 2017). In brief, the Delphi technique is a multi-round open-ended survey, in which experts are asked to respond to particular prompts (e.g., in this case, the components of a university innovation ecosystem) (Hsu and Sandford, 2010). After each round, collected data is analyzed and the items are refined based on the views of participants; this process is completed until consensus is reached, typically requiring three to four iterations. The Delphi technique is ideal for establishing a consensus on questions that are somewhat subjective or that do not have a high degree of objective consensus (Hsu and Sandford, 2010). However, it does have weaknesses, including the sample size (even though expert) being limited, and therefore findings cannot be generalized to broader contexts (Galanis, 2018). Thus, the Delphi technique is used only for the initial stage of the research, to develop the initial research instrument.

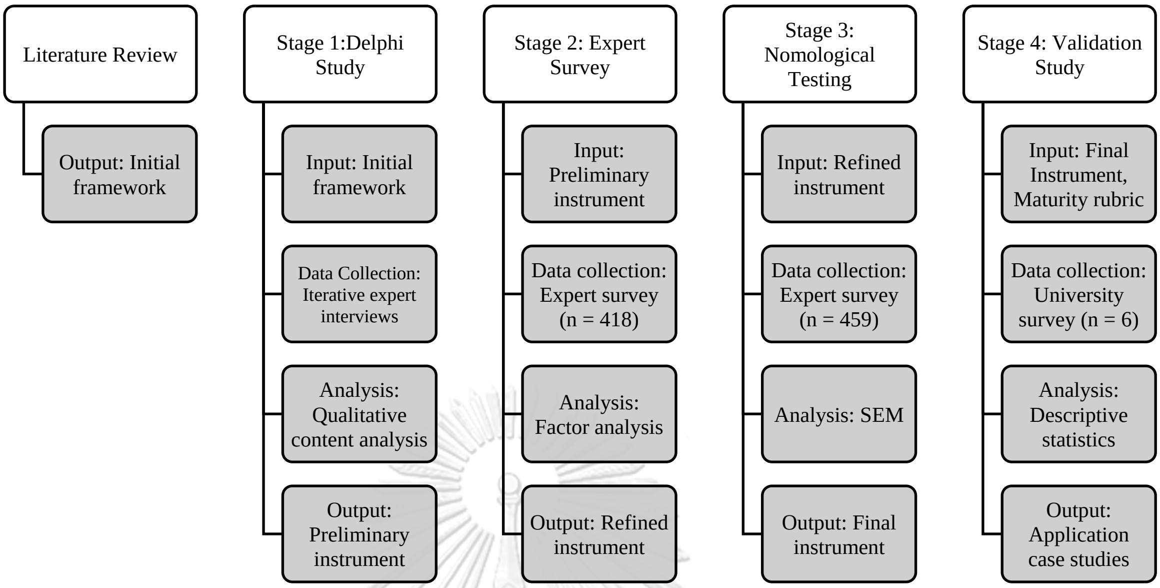
Stage 2. The research instrument derived from the Delphi study was used in an initial expert survey, drawing on university leaders, innovation policymakers, educators and researchers, innovation coordinators, and private-sector innovation partners from the ASEAN region. The initial expert survey was developed in order to test the proposed innovation research model's reliability and validity and evaluate the items included within it, which can be classified as testing of the measurement model (Brown, 2015). The reason for choosing a quantitative survey approach here was to apply the initial theoretical model across a wider sample of experts, which would either validate or reject the proposed relationships (Fowler, 2014).

Stage 3. The third research stage used the refined model derived from the factor analysis in Stage 2. Nomological testing was used to investigate the nomological validity of the proposed model, or in other words the validity of both the proposed constructs and the relationships between them (Cronbach and Meehl, 1955; Smith, 2005). Nomological validity testing is still an area of research that is under theoretical development, and therefore there is no consensus approach to testing it (Liu et al., 2012). However, there are a variety of recognized approaches that have been proposed, including Structural Equation Modeling (SEM) and canonical correlation analysis (Byrne, 1984). In this research, a SEM approach was used, as this was the most appropriate approach for the research design and data.

Stage 4: The final stage of the research was a validation study, whose purpose is to assess the usability of an instrument as applied in real-world contexts (Whiteman and Shorkey, 1978). To begin the validation study, the researcher employed the final instrument (the output of Stage 3) to develop a maturity rubric and scoring schedule for application within a live university. The maturity rubric was then used to collect data from six respondents, who were highly positioned policymakers and leaders of innovation policies at three Thai universities. Descriptive statistics were then calculated using the scoring schedule. A case study for each of the universities was developed based on the scoring mechanisms, showing how the maturity rubric could be used to assess strengths, weaknesses, and opportunities for improvement.

The specific implementation and techniques of each of the four stages of research are explained in the sections below.

Figure 11 The research process



3.2 Stage 1: Delphi Study

3.2.1 Population of interest and sampling

The Delphi technique is an expert research tool, meaning that it draws on populations of individuals with acknowledged education, experience and general expertise in a field (Hsu and Sandford, 2010). The Delphi study had the narrowest definition of expertise, including only individuals that have current, central roles in ASEAN universities in the field of innovation management. These specialists included innovation directors (policymakers), innovation hub coordinator and commercialization specialists, and educators and researchers who are directly involved in innovation research and/or commercialization. However, it excluded educators and researchers not directly involved in innovation research and/or commercialization, policymakers in other areas, and staff members whose roles are not directly involved in the innovation process. While including these individuals could have some value as a form of crowdsourcing (Flostrand, 2017), they would not have been able to contribute detailed information regarding expert consensus (Ogbeifun et al., 2017). Following the Delphi technique's direction, experts were purposely selected from a variety of institutions in ASEAN. The selection included at least two experts from each country and included experts from several different universities.

The final panel included 40 experts. These experts were recruited through a combination of direct contact and referrals from other participants, and all qualifications were independently confirmed through university websites before inclusion.

3.2.2 Instrument Design

There were three instruments designed for the Delphi study (attached in Appendix A), with one instrument for each round of the study. The instruments were designed using categorical items, which allowed for rapid evaluation of consensus on the individual items, which is the objective of the Delphi study (Galanis, 2018). There were also open-ended items used to collect additional information (Brace, 2018), such as suggested categories and items.

At each stage, pre-testing with volunteer testers was used to evaluate face validity and ensure there were no difficulties with wording in the items (Brace, 2018). This pre-testing, which was conducted prior to each of the questionnaire distributions, was also used to ensure there were no duplicate items. The content and approach of each of the items is described below.

Round 1 (Exploration). The first instrument was designed for Round 1 (Exploration). For this stage, a maximalist approach was used to select items. The instrument consisted of a total of 138 items, which were developed from the instruments used in the conceptual framework sources (Kirby et al., 2011; Guerrero and Urbano, 2012; OECD, 2012; National Science Technology and Innovation Policy Office, 2018). The items were loosely organised into the five dimensions of the university innovation ecosystem (Leaders and Governors, Educators, Innovators, Connectors, and Agents of Change). However, these classifications were not disclosed to the participants. Respondents were presented with one item at a time in random order. They were asked two questions for each item: 1) Should this item be used to measure university innovation ecosystem performance? [Yes/No] and 2) Which of these actors has the primary responsibility for this item? [Leaders, Educators, Innovators, Connectors, Agents of Change]. At the end of the questionnaire, respondents were asked whether there were any missing items that should be included to measure the university innovation [open-ended response].

Round 2 (Development). The second instrument was designed for Round 2 (Development). In this round, the items that gained substantive consensus (discussed below) were included, along with new items that were suggested in Round 1. Here, there were a total of 115 items, each of which had a preliminary assignment of actor responsibility from Round 1. They were presented items one at a time in random order, with three questions asked for each item. Following Brennan et al. (2014), the central dimensions (Leaders and Governors, Educators, Innovators, Connectors, and Agents of Change) were described as actor groups, in order to ensure that these primary dimensions are understood as either groups or individuals. These questions included: 1) Should this item be used to measure university innovation ecosystem performance? [Yes/No] 2) Does [Actor group] hold primary responsibility for this item? [Yes/No] and 3) Please assign the item to one of the proposed functional responsibility areas [Multiple choice] or suggest another item [open-ended response].

Round 3 (Confirmation). The third instrument was developed for the Confirmation round of the Delphi study. Only closed-ended categorical items were used in this stage, as the purpose of this stage was to confirm the structure of the model and assignment of the items to dimensions and sub-dimensions. There were 93 items that had gained consensus in Round 3. For each of the items, respondents were asked three questions: 1) Should this item be used to measure university innovation ecosystem performance? [Yes/No] 2) Does [Actor group] hold the primary responsibility for this item? [Yes/No] and 3) Does the item fall into [Functional group]? [Yes/No] As in Round 2, Actor Groups included Leaders and Governors, Educators, Innovators, and Connectors, although Agents of Change had been eliminated in the previous stage.

3.2.3 Data collection

Data collection was accomplished using three rounds of open-ended surveys, which is usually sufficient to reach a high level of consensus on all but the most controversial questions (Hsu and Sandford, 2010). Although an additional round was scheduled, it was not required after the final analysis. The surveys were distributed to the participants each time via a Google Forms file, which enabled data collection without unnecessary exposure risk to COVID-19. Following the Delphi technique, the initial round included the draft innovation framework and assessment items as derived from the literature review. Each subsequent survey had refined items based on the feedback from the earlier round.

The Delphi surveys consisted of three types of questions. First, respondents were asked to rate the relevance of each item to university innovation, using a Likert scale (1 to 5) (Galanis, 2018). Second, respondents were asked to place the item within a dimension of the university innovation ecosystem, using a set of fixed-choice dimensions which were gradually refined over successive rounds. Third, an open-ended response item allowed for provision of feedback on wording, measurement or other issues of concern, as well as suggestion of missing or additional items.

3.2.4 Data analysis

Data analysis was conducted iteratively, with a full analysis after the close of each round of data collection. There are a variety of techniques that can be used in Delphi surveys, depending on the sample size (Hsu and Sandford, 2010). A combination of two analysis approaches were used here. First, simple percentages were calculated for agree/disagree with individual items, which allowed for the researcher to determine whether consensus had been reached. The second technique was Qualitative Content Analysis (QCA), which is a systematic qualitative data analysis technique designed for use with texts (Drisko and Maschi, 2016). There are two different approaches to content analysis, including QCA and quantitative content analysis (commonly just called content analysis) (Krippendorff, 2018). The quantitative content analysis approach is a process of summation and counting of specific words and quantitative description of the relationships between them (for example, relationships between words or use of specific phrases) (Krippendorff, 2018). This form of content analysis can be helpful for questions in domains like linguistics, or in areas where there is a large volume of data, like analyzing online reviews, but it is not as useful in smaller datasets (Krippendorff, 2018). Unlike quantitative content analysis, QCA does not rely simply on counting occurrences of words or phrases in a text, but instead focuses on the interpretation and meaning of the words and phrases used. QCA is performed using a coding frame, which is a set of codes used to descriptively identify textual information (Schreier, 2014). The choice of coding frame and the approach to its development is based on what is intended to be discovered for the analysis and the level of detail that is of interest (Schreier, 2014). There are different approaches to developing a coding frame for application to the texts, including the conventional approach of deriving the coding frame from the process of coding, the directed approach, in which it is developed from the literature review, and a summative approach, which is similar to quantitative CA in that it uses summation and counting of specific words and interpretation of the codes (Hsieh and Shannon, 2005). Regardless of the approach used, the formation of the coding frame is a critical step in the coding process, because it establishes what codes will be used to interpret and compare texts (Schreier, 2014).

The QCA process used a conventional approach, in which the coding frame is developed from the text itself (Hsieh and Shannon, 2005). The researcher began coding each survey as it was received. Once no additional codes were developed from surveys (the point of theoretical saturation (Hennink et al., 2020)), the researcher stopped the initial coding round and refined the coding frame by removing duplicated codes, collapsing similar codes and grouping codes. The entire dataset was then recoded using the refined coding process.

After Round 1, items with poor consensus (mean <0.5 on relevance, indicating less than 50% agreement) were eliminated. The elimination of poor consensus items is one of the stages in the Delphi study process (Galanis, 2018). The 50% threshold for agreement was selected because the first round of the Delphi study is intended to reach a rough consensus and eliminate all items which were substantially disagreed with, and is one of the commonly used consensus levels for first rounds (Zartha Sossa et al., 2019). Studies do use different levels of consensus during the rounds, as shown by Zartha Sossa, et al. (2019), but the use of this level was considered to be an expensive measure that ensured that more people than not agreed with the item. Additional items and changes to wording were incorporated as well. For the final round, items with only moderate consensus (mean <0.75 on relevance, indicating less than 75% agreement) were eliminated, and respondents were asked to confirm the final role and placement. The 75% consensus level, which meant that at least three in four of the experts agreed with the item and its placement, was appropriate to indicate a moderately high level of agreement with the item and its placement (Galanis, 2018). The output of the final round of data analysis was the preliminary innovation model and measurement, which was used as the input for Stage 2 (Expert Survey).

3.3 Stage 2: Expert Survey

3.3.1 Population of interest and sampling

The expert survey drew on a wider sample of experts from universities in ASEAN. Here, a wider definition of experts was used, including the university leaders and policymakers, educators and researchers, innovation coordinators and other experts, and representatives of innovation partners, including government agencies, Non-Governmental Organizations (NGOs) and private-sector enterprises. The sample was collected using network sampling, in which the initial sample was asked to refer interested others to the survey (Heckathorn and Cameron, 2017). In network sampling, respondents are initially selected using purposive sampling, in which the researcher identifies participants who meet the requirements of the sample. In this study, the purposive sampling was based on known expertise and role in the target organization. These participants are then asked to refer people they know that also meet the criteria of the study, which in this study was done using a referral link to the survey. The referral link, which was generated uniquely for each of the participants who completed the survey, allowed the researcher to ensure that the participants were referred by others, and were therefore likely to be in the population of interest (Heckathorn and Cameron, 2017). It was also used to track rounds of referrals, which offered a general idea of how effective the sampling procedure was (Heckathorn and Cameron, 2017). Through multiple rounds of referrals after the initial purposive sampling, the randomness of the sample is increased and the researcher can reach sparse populations (Heckathorn and Cameron, 2017). The initial wave included 50 participants the researcher identified, and purposely recruited, and remaining participants came from subsequent referral waves.

The minimum sample size was based on the analysis method and the intent of this stage of confirming the measurement model. Minimum sample sizes can vary widely in factor analysis and structural equation modeling (SEM) research depending on the measurement model and other factors (Wolf et al., 2013). Factor analysis and SEM were selected because they are ideal for investigating the structure of theoretical models, such as the one developed here, and associating observed variables (such as the sub-dimensions of the conceptual model) with latent variables (as represented in the primary dimensions) (Byrne, 2016). Therefore, the choice was made to use these tools despite the larger sample size requirement. Using the draft assessment from the Delphi study, it was calculated that a minimum of 200 participants would be needed for this purpose (Soper, 2020). The actual sample size (n = 418) exceeded this limit, indicating it was adequate for the research.

3.3.2 Instrument design

The instrument (attached in Appendix B) used the items that were derived from Round 3 (Confirmation) of the Delphi study, which was described in the previous section (3.2.2). Therefore, there were 91 items in the survey. These items were measured using a five-point Likert scale. Likert scales are ideal for assessment of agreement, opinions, and other perceptions that do not have a clear objective scale (Brace, 2018).

The main question that respondents were asked about each item was: "How important do you think this item is for an innovative university?" Respondents were given five choices, including: (1) Not at all important; (2) Not very important; (3) A little important; (4) Somewhat important; and (5) Very important. There was some questioning about how many points to use within the Likert scale, given concerns such as, tendency toward central selection (Pimentel, 2019) and whether it can be treated as an interval scale (Wu and Leung, 2017). However, given the potential range of variation in importance attitudes, it was decided that a scale longer than five points would be false precision, but shorter than five points would limit the range of importance assessment. Therefore, the five-point scale was viewed as most appropriate.

3.3.3 Data collection

Data collection was conducted using an online survey, hosted on Google Forms. The survey was presented as a scenario analysis, rather than analysis of the actual universities where participants worked. Each of the items in the preliminary instrument was presented as a hypothetical, for example, “In the innovative university, university vision is oriented to vision and entrepreneurship” (Item V1). The items were measured using a Likert scale; (1) Strongly disagree; (2) Disagree; (3) Neutral; (4) Agree; and (5) Strongly agree. In addition, respondents were asked to provide basic institutional data, for a participant profile.

3.3.4 Data analysis

Following data collection, analysis was conducted in SPSS AMOS. The Confirmatory Factor Analysis (CFA) process was used for the process. This tool was selected because it is ideal for evaluation of measurement models, for example, allowing the researcher to investigate the structure of latent variables and move or eliminate items as appropriate to refine the measurement model (Brown, 2015). The CFA models were constructed independently for the dimensions of Leaders and Governors, Educators, Innovators, and Connectors.

Assessment of the goodness of fit is an essential step in CFA, as it evaluates the extent to which the model accurately reflects the observed data (Brown, 2015). Goodness of fit measures assess the overall fit of the model compared to the observed data (Brown, 2015). While these measures are broadly similar, they have different calculation methods and are prone to different biases, meaning that the use of multiple measures is recommended (Brown, 2015). These measures should include both absolute and relative fit measures (West et al., 2012). The difference between these two types of measures is that absolute fit measures are not using alternative sets of model assumptions, while comparative fit indexes do use different models (such as the saturated model) to investigate which model is the best description for the data (West et al., 2012).

Several fit measures were used, including both absolute and relative fit measures, because goodness of fit measures typically contain some amount of bias related to the sample size or distribution (Shi, Lee and Maydeu-Olivares, 2019). The measures used include comparative fit index (CFI) (>.90) and Tucker-Lewis Index (TLI, also known as the non-normed fit index or NNFI) (>.90), chi-square ($p < .05$) and root mean square error of approximation (RMSEA) (<.06) (Hu and Bentler, 1999; Kenny, Kaniskan and McCoach, 2015). CFI is a relative fit index which adjusts the model to compensate for sample size, which means it does not have the sample size bias that occurs in absolute measures such as the chi-square test (Hu and Bentler, 1999). The TLI (or NNFI) was selected, rather than the normed fit index (NFI) alternative, because the original NFI was prone to negative bias (Shi, Lee and Maydeu-Olivares, 2019). The TLI adjusts for this problem, although some negative bias can remain (West, Taylor and Wu, 2012). RMSEA was selected as the absolute fix index because, unlike other absolute fit indices such as the goodness of fit index (GFI), it is less susceptible to sample size bias (Kenny, Kaniskan and McCoach, 2015). Therefore, these three measures were identified as being a good balance of absolute and relative fit indices that were somewhat resistant to the biases of other fit indices.

Model reliability and validity was tested using standard rules of thumb including composite reliability (CR) (> .70), average variance extracted (AVE) (>.5), and mean squared variance (MSV) (< AVE) (Fornell and Larcker, 1981; Hair et al., 2016). These measures allow for assessment of the overall reliability (the overall consistency of measurements) and convergent and discriminant validity (the extent to which measures correlate with theoretically related variables and do not correlate with theoretically unrelated variables) (Hair et al., 2016).

The final stage of analysis for the CFA process was model assessment and reduction, which was done using the factor loadings for individual items on their proposed items (Brown, 2015). The purpose of this process was to remove any items that were not related to their proposed dimension. Using a standard rule of thumb for evaluating factor structure, observed variables with a factor loading of <.60 on their proposed latent variable (or dimension) were removed (Brown, 2015; Hair et al., 2016). The refined model was then used to develop the questionnaire for Stage 3: nomological testing.

3.4 Stage 3: Nomological Testing

3.4.1 Population of interest and sampling

The population of interest for the nomological testing was the same population as for Stage 2 in terms of expertise and innovation roles in universities. However, rather than only focusing on ASEAN, participants were drawn from across the Asia Pacific region. This choice was made to widen the measurement and ensure that the model was valid outside the context of ASEAN.

The sample was selected using network sampling (Heckathorn and Cameron, 2017), beginning with a starting point of the pool of participants from the initial survey. An additional 50 further potential respondents were purposely selected by the researcher from universities and other organizations outside ASEAN, to seed the Asia Pacific respondents. The initial wave yielded 105 respondents, who in turn referred additional participants in four additional waves. The final sample size for the nomological testing was 459 members. This sample size was somewhat larger than the minimum sample size required for the model structure at an anticipated effect size of .25 (medium effects) (Soper, 2020). Therefore, the sample size was adequate for the research.

3.4.2 Instrument design

The instrument for nomological testing (attached in Appendix B) was the same instrument used in Stage 2 (Expert Survey). The instrument design is explained in full in section 3.3.3. As a review, the instrument consisted of 91 items which were derived from Round 3 (Confirmation) of the Delphi study. The main question that respondents were asked about each item was: “How important do you think this item is for an innovative university?” Respondents were given five choices, (1) Not at all important; (2) Not very important; (3) A little important; (4) Somewhat important; and (5) Very important. These choices were measured using a five-point Likert scale, which was selected because Likert items are appropriate for measuring non-objective or inexact concepts (Brace, 2018).

3.4.3 Data collection

Data collection was performed using essentially the same strategy as Stage 2. The refined questionnaire from Stage 2 was used for scenario assessment of an ideal university. Respondents were asked to respond with their level of agreement for each item, using a Likert scale; (1) Strongly disagree; (2) Disagree; (3) Neutral; (4) Agree; (5) Strongly agree.

3.4.4 Data analysis

Data analysis was conducted in SPSS, as it had been for earlier studies. The analysis began with CFA, which followed the same process as in Stage 2. The purpose of the CFA process was to investigate whether the model's structure remained similar in the context of a broader sample, which is in part the purpose of nomological validity testing (Liu et al., 2012). The second stage of the process examined the relationships of the proposed first-order constructs (e.g., Vision, Policies and Strategies) and second-order constructs (e.g., Leaders and Governors), in order to investigate whether relationships are strong and consistent. This helped to identify unrelated or redundant first-order constructs, and determine the overall validity of the model.

Goodness of fit was tested using the same measures as profiled in Stage 2, including CFI (>.90). TLI (>.90), and RMSEA (<.06) (Hu and Bentler, 1999; Kenny, Kaniskan and McCoach, 2015). Model validity and reliability was also assessed using the same measures, which included CR (> .70), AVE (>.5), and MSV (< AVE) (Fornell and Larcker, 1981; Hair et al., 2016).

The CFA process yielded factor loadings (or path coefficients), which were used to investigate the overall strength of relationships. There is no strict guideline in nomological validity testing on exactly how strong a relationship should be to be maintained, which is in part due to the developmental stage of the nomological testing process itself (Shultz et al., 2020). Due to the context of this research, a moderately high level of validity was needed, but as this was not a psychological test or other assessment, it was not a case where very high levels of validity were demanded (Shultz et al., 2020). Factor loadings are coefficients (ranging from 0 to 1) which represents the strength of an observed variable to an underlying factor (or latent variable) (Brown, 2015). Therefore, variables with lower factor loadings have a weaker relationship to the unobserved variable of interest, while those with higher factor loadings have a stronger relationship to the observed variable of interest. By selecting variables with a higher factor loading to include in the factor, this means the model provides the most reliable representation of the underlying variable (Brown, 2015).

A factor loading of >.60 was used for acceptance of the relationship of first-order and second-order constructs. This threshold is typically interpreted to indicate that the factor is definitely related to the unobserved variable in question (Brown, 2015), making it a suitable limit for inclusion. Relationships with factor loadings between .40 and .60 were investigated to determine if they could be improved through further refinement of the measurement model for the underlying variable (Brown, 2015). These factor loadings are considered to be moderate or marginal relationships, meaning that their relevance to the unobserved variable could be improved through processes like model reduction, where poorly related variables are removed from the model (Brown, 2015). Relationships with factor loadings of <.40 were eliminated, because they were considered unreliable, as this is considered a weak level of factor loading which indicates the observed variable is not really related to the unobserved variable (Brown, 2015).

3.5 Stage 4: Validating the Finalized Model

Following the nomological testing, a final validation of the model was conducted. This validation process was structured as a multiple case study, which is a detailed investigation of a small number of known cases of a phenomenon (Gerring, 2017). The purpose of this stage was to identify any potential problems with the structure and application of the model in the context of the real university. The validation stage was conducted as a small-scale quantitative study, which used descriptive statistics to assess the rubric developed to measure university innovation ecosystems. This stage was therefore essential in the commercial development of the instrument.

3.5.1 Population of interest and sample

This stage of the research was conducted at the university level. Therefore, the population of interest was universities in Thailand that are in the process of developing, or have developed a university innovation ecosystem. Universities were selected purposely. Purposive selection is used in case studies to make sure that the cases are reflective of the situation of interest (Yin, 2018). In this study, universities were selected based on their interest in development of university innovation ecosystems, and had begun (though not necessarily completed) the process of university innovation ecosystem development. There were three universities selected for the study, including Chulalongkorn University (CU), Kasetsart University (KU), and Chiang Mai University (CMU). Each of these universities has been provided with a pseudonym for this report. These universities are all at different levels of innovation ecosystem development, but they all have an interest in and dedication to further development.

For each of the universities selected, two representatives were recruited to complete the innovation rubric for the university. Two representatives were necessary to address respondent bias through the use of a multi-rater approach (Jeong et al., 2018).

These representatives were selected using expert sampling (Chaudhuri, 2019), meaning that they were purposely selected based on their knowledge of and involvement in the university's innovation process. Therefore, the final sample of the study included six respondents. Positions of respondents varied, but included innovation directors, entrepreneurship hub coordinators or managers, and innovation policy and innovation management specialists.

3.5.2 Instrument design

The instrument used for this study was an assessment rubric, designed to assess the overall level of implementation within the university. The base items were the same as those used in the Stage 2 and Stage 3 testing (attached in Appendix B). However, the rubric was designed to assess the overall implementation level in the university. The measurement strategy for the rubric used a six-point Likert scale, with measurement levels based on the Capability Maturity Model Integration (CMMI) approach (Constantinescu and Iacob, 2007). The CMMI approach was selected for the rubric measurement strategy because it allows for universities not just to assess what they are currently doing, but to identify areas for improvement and development (Duarte and Martins, 2013). This made it a more useful approach to measurement than alternatives like the importance-performance analysis (IPA) approach, which assesses the current performance and relevance of each item (Oh, 2001). IPA is widely used for assessing current performance in areas like service quality, and it is effective for gap analysis (Feng et al., 2014). However, since this model was also intended to provide insights into how the innovation ecosystem could be developed past the current stage, the CMMI was a better choice.

The CMMI is a five-level model, which can be defined as follows:

0: Incomplete – There is not yet any serious attempt to implement the process.

1: Performed – The process is performed in a bottom-up or ad hoc way, but is not yet actively managed.

2: Managed – The process is reactively managed on a project or group level.

3: Defined – The process is understood and defined at the organization level, and is implemented into organization-wide policy.

4: Quantitatively managed – Processes are defined, measured, and actively controlled to provide predictable and goal-oriented results.

5: Optimizing – Processes have achieved a stable implementation and are proactively adjusted using continuous improvement to improve outcomes (O'Regan, 2010).

These levels were used as the basis for the individual item assessments, with Likert items ranging from 0 to 5 to correspond to each of the items. The assessment rubric is presented in Appendix D. A closed-ended Likert scale was selected for the rubric because it would allow for overall assessment of the maturity of each of the instruments, and would therefore allow the university to identify trouble spots.

3.5.3 Data collection

Data collection was performed using an online questionnaire (email), as was used in the earlier stages of data collection. After recruitment of participants, each participant was sent a link to the questionnaire. The questionnaire asked the participants to select the appropriate level for their university as their innovation ecosystem was at the time. Following completion of the questionnaire, respondents were then thanked and asked whether they wanted to receive the scored rubrics and assessment for their university.

3.5.4 Data analysis

Data analysis was conducted using the scoring model planned for implementation of the assessment rubric. For each individual item a total of five possible points was assigned. These points were based on the Likert items measured within the scale. Individual item scores were then averaged based on the number of responses given. The total number of points for each sub-dimension were then added together. So for example, the Governance and Culture (GC) sub-dimension, which has three items, had a maximum possible score of 15. The sub-dimensions within each of the four lead dimensions (Leaders, Educators, Innovators, and Connectors) were then added together. Therefore, the Leaders dimension (29 items) had a maximum possible score of 145. The scores were then divided into quartiles to provide a level, using the CMMI levels as previously discussed (Constantinescu and Iacob, 2007; O'Regan, 2010; Duarte and Martins, 2013). This led to the scoring metric for the dimension, sub-dimension, and individual item levels; (0) Incomplete; (1) Performed; (2) Managed; (3) Defined; (4) Quantitatively managed; and (5) Optimizing (see the detail in section 3.5.2).

Finally, the dimensional scores are measured to determine the overall innovation maturity level of the university. The mean range was based on the previous studies (Constantinescu and Iacob, 2007; O'Regan, 2010; Duarte and Martins, 2013)

This scale includes the following points, representing the overall level of innovation ecosystem maturity within the university:

Level 1: Ad Hoc (0 to 1.49 points)

Level 2: Piloted (1.5 to 2.49 points)

Level 3: Managed (2.5 to 3.49 points)

Level 4: Institutionalized (3.5 to 4.49 points)

Level 5: Optimized and Integrated (4.5 to 5 points) (Constantinescu and Iacob, 2007; O'Regan, 2010; Duarte and Martins, 2013).

3.6 Ethical Considerations

There are several ethical considerations at play in this research. Participant protection, especially of interviewees, is of special concern in this research because of the potential risk to participants in Stage 1, where it is possible that there could be inadvertent disclosure of confidential or sensitive information. Ethical research requires that researchers control the potential risk to participants as well as, if possible, providing the participants with a benefit (Kara, 2018). For this research, the benefit will be the completed model, which can be used by university administrators to refine their university's innovation ecosystem. However, there is still a need to prevent risk of exposure and maintain confidentiality. The issue of accidental disclosure was limited both because of the researcher's qualitative oversight of the data (which allowed for discarding any accidental disclosure of seemingly confidential information), and because of the iterative nature of the Delphi process (Hsu and Sandford, 2010), which meant that experts were given a chance to review their own contributions and those of others. This essentially provided the same level of protection as member checking, where participants are offered a chance to review and withdraw sensitive information

(Hennink et al., 2020). The expert surveys for Stages 2 and 3 were conducted anonymously, with no personally identifying information other than institutional position, in order to protect participants from disclosure (Fowler, 2014). Combined with no individual data being released, this prevented accidental disclosure.

3.7 Chapter Summary

This chapter has explained the research design and processes of data collection and analysis that were used to develop and test the university innovation model. The research begins with a Delphi study, which through several rounds of iterative data collection established a consensus on the components and characteristics of a university innovation ecosystem in ASEAN and how they can be measured. The preliminary instrument developed through the Delphi study was then applied across a larger sample of experts in an expert survey, which allowed the researcher to conduct factor analysis and refine the model and instrument. This refined instrument was then used again in a larger expert survey, this time with the intention of testing the nomological validity of the model using SEM. Finally, the validation stage provided that the maturity rubric and scoring system allowed for the test of the model in a real-world application. This research design allowed for careful refinement of the university innovation ecosystem model, an essential aspect of its usability in the university environment. In Chapter 4, the findings from these four research stages are presented.

CHAPTER IV
FINDINGS

In the previous chapter, it was explained that the primary research was conducted using a qualitative-led, exploratory instrument development design. This design had three stages, including a Delphi study, an expert survey, and a second expert survey, used for nomological testing of the proposed structure of relationships. The goal of this chapter is to present the findings from each of these three stages of research.

The chapter begins with the presentation of findings from the Delphi study. Here, a brief overview of the outcomes of each of the three rounds of expert opinion are presented. The section closes with an overview of the preliminary instrument. The next aspect reviewed is the expert survey, which was conducted among experts in ASEAN to test the initial framework of the study. This section closes with a review of the revised instrument. The third section of the chapter presents the results of the nomological testing, which evaluates both how reliable the model was in a broader sample and how closely connected the first-order and second-order constructs are. This section closes with a review of the final instrument that emerged from the study. The final section of the chapter discusses the findings with the literature review, to situate the research in theoretical and empirical context.

4.1 Stage 1: Delphi Study

4.1.1 Participant profile

The first stage of research was a Delphi study, which included 40 experts from a restricted range of countries (the ASEAN+3 countries). Table 5 summarizes information about the participants. All participants came from different universities. Although the purposive selection did not try to select participants strictly by country size, there were more participants included from larger countries than from smaller countries. Participants by country included: Brunei Darussalam (n = 2); Cambodia (n = 2); Indonesia (n = 3); Laos (n = 2); Malaysia (n = 4); Myanmar (n = 1); Philippines (n = 2); Singapore (n = 3); Thailand (n = 5); Vietnam (n = 2); China (n = 7); Japan (n = 4) Korea (n = 3). Participants also had a wide range of positions. In general, they can be classified as policymakers (n = 8), educators (n = 7), researchers (n = 14), commercialization experts (n = 11). Table 6 shows university ranking based on the Times Higher Education (THE) (2022) global university rankings. As this shows, there were 12 experts from universities at universities ranked between first and 50th on the THE global university rankings, accounting for 30% of the sample. The largest group of 18 participants (or 45% of the sample) were from universities ranked between 51st and 100th. The smallest group of 25% (n=10) were from universities ranked at over 100.

Table 5 University ranking based on Times Higher Education (2022) Global University RankingsSource: Times Higher Education (2022)

Ranking	Number	Percent
1-50	12	30%
51-100	18	45%
More than 100	10	25%
Total	40	100%

4.1.2 Descriptive results

The Delphi study was conducted across three rounds. In Rounds 1 and 2, items with low consensus were removed, and additional items and wording changes were incorporated into the next stage. In Round 1, items with under 50% agreement were removed, and in Round 2 items with under 75% agreement were removed. These levels of consensus were identified as commonly used to indicate majority consensus and moderate consensus respectively, as discussed in Chapter 3 (Galanis, 2018; Zartha Sossa et al., 2019). In Round 3, items without high consensus (Under 90% agreement) were removed, leaving only the most agreed on items. Table 7 summarizes the outcomes and items from each of these stages.

Round 1 (Exploration) was the initial exploration of items and factor structure. In Round 1, a total of 138 items were proposed; 28 additional items were added, but 51 items were removed. This resulted in a total of 115 items for the second round. Notably in this stage, the entire Agents of Change dimension was eliminated due to lack of consensus. Comments on this item indicated that the items were either redundant or completely subsumed in other dimensions and therefore there was no distinct Agents of Change dimension. Some of these comments included:

"This item is redundant, as any member of the university can act as a change agent."

"This item overlaps with the Leaders and Governors measure."

"There is no clear reason to have a different Agents of Change dimension in the model."

"Any of the other dimensions act as agents of change, too. I am not certain that there is a reason to have a distinct dimension."

Overall, the experts in the study were not supportive of the distinctiveness of the Agents of Change dimension from the other dimensions, with items potentially identified for Agents of Change rejected or assigned to other items. This dimension also had some of the weakest support in the literature, meaning it was theoretically not well supported.

Thus, this dimension, although it is included in the conceptual framework (Figure 9 in Chapter 2) was eliminated from the model at the earliest stage of primary research.

These items were assigned to broad functional dimensions, including Leaders (31 items), Educators (24 items), Innovators (33 items), and Connectors (16 items). The items that were added in this stage were primarily items concerned with objective measurement of outcomes such as revenue generation and funding, which had not been incorporated into the initial model. Although the evidence from the literature review did suggest that these elements may be over-emphasized in existing models, the researcher did consider that these measures would also be critical for university assessment and comparison of innovation activities (Guerrero et al., 2016). Thus, they were added to the items. Most of the removed items were those which participants felt were either only marginally related or which did not have a good way to measure it. For example, an initial item proposed for Educators was “external speakers on innovation and entrepreneurship are recruited for on-campus events”, which participants felt was both marginally related and which overlapped another item (CT4). Thus, the refined items presented in Round 2 were more objective and more focused than the items initially selected.

Round 2 (Development) further developed the model by presenting the added and refined items from Round 1 and refining the categories and constructs items were assigned to. Of the initial 115 items included in this stage, there were a total of 22 items removed due to low consensus. Thus, this stage concluded with 93 items. Respondents were also asked to assign the items to more refined categories, with between three and eight refined categories per overall dimension.

Round 3 (Confirmation) was the final stage, in which the research model derived from Round 2 was presented for final approval from experts and no further changes implemented. This stage began with 93 items proposed, of which two items (in the Educators category) were removed due to low consensus. Thus, the final statement of the preliminary measurement instrument contained 91 items.

4.1.3 Final outcome of the Delphi study

The preliminary instrument developed from the Delphi study is summarized in Table 7. The summary was produced from each round of the Delphi study, in which the expert panel was presented with a list of dimensions and items and asked to assign items to dimensions (either freely or using an increasingly constrained set of choices.) The full process of the Delphi study is discussed in the methodology (Section 3.2.)

This instrument was used as the input for Stage 2 (Expert Survey), whose outcomes are reported in the following section. The numbering of items remains the same throughout the following two sections, and no additional changes are made to wording of items based on Stages 2 and 3. Therefore, Table 7 also serves as a reference for the texts of the items in the refined instrument (developed in Stage 2) and final instrument (developed in Stage 3).

Table 6 summarizes the outcomes for each of the items across the three rounds of exploration. For each of the primary dimensions (Leaders and Governors, Educators, Innovators, Connectors, and Agents of Change), the total number of items included in each stage is included. Stages 2 and 3 also include the number of items assigned to each of the sub-dimensions. Each of the individual dimensions also includes a cumulative mean figure, which indicates the consensus level at each stage. For example, it can be seen that the Governance and Culture (GC) dimension had an agreement level of 0.65 in Round 1, rising to 0.78 in Round 2 with three items assigned, and to 0.93 in Round 3 with three items assigned.

Table 6 Summary of the Delphi study rounds and outcomes

		Round 1 Exploration		Round 2 Development		Round 3 Confirmation	
Dimension	Sub-Dimension	Items	Cum. Mean	Items	Cum. Mean	Items	Cum. Mean
Leaders		31		29		29	
	Governance and culture (GC)		.65	3	.78	3	.93
	Policies and Strategies (PS)		.83	11	.85	11	.90
	Resource management (RM)		.68	5	.85	5	.90
	Stakeholder engagement (SE)		.70	5	.93	5	.93
	Vision (V)		.85	5	.90	5	.90
Educators		24		22		20	
	Curriculum and teaching (CT)		.80	12	.85	10	.93

		Round 1 Exploration		Round 2 Development		Round 3 Confirmation	
	Industry involvement (II)		.70	3	.85	3	.90
	Learning outcomes (LO)		.92	7	.95	7	.95
Innovators		33		27		27	
	Production (IP)		.90	3	.90	3	.90
	Commercialization (IC)		.85	3	.90	3	.90
	Funding and Financial Management (FFM)		.88	6	.90	6	.93
	Incentive and Reward Systems (IRS)		.70	3	.85	3	.95
	Training and Mentoring (TM)		.78	3	.83	3	.93

		Round 1 Exploration		Round 2 Development		Round 3 Confirmation	
	Role Models (RM)		.73	3	.83	3	.90
	Business and Innovation Development (BID)		.60	3	.75	3	.90
	Faculty Involvement (FI)		.58	3	.85	3	.95
Connectors		16		15		15	
	External collaboration (EC)		.75	3	.90	3	.93
	Internal collaboration (IC)		.70	3	.83	3	.93
	Industry connections (ICO)		.63	3	.83	3	.93
	Entrepreneurial Education (EE)		.80	3	.85	3	.95
	Entrepreneurial Hub (EH)		.75	3	.80	3	.93

		Round 1 Exploration		Round 2 Development		Round 3 Confirmation	
Agents of Change	Change Agents	0	.40				
Total items proposed in Stage		138		115		93	
Items added in Stage		28		0		0	
Items removed in stage		51		22		2	
Items retained in stage		115		93		91	

Note: Cumulative means of sub-dimensions are of all items initially included in the study, including those that were eliminated due to low consensus during the round

During this stage, the members of the expert panel (n = 40) were asked to vote on whether the initial items were relevant to the university innovation ecosystem; sort the items into their most suitable dimensions; and to suggest any items that were missing. This stage of the Delphi study resulted, as expected, in a significant change in the items and underlying instruments, as respondents challenged many of the items that had been identified from the literature and identified others. The biggest change at this stage was that the responses did not support the ‘Change Agents’ dimension at all as part of the university innovation ecosystem. While this was surprising, the main rationale for this – that all items were relevant to other dimensions, and that any member of the university could act as a change agent – were very relevant to the findings.

Therefore, this was acknowledged in the design of the later study. The results for this stage are as follows.

This stage began with a total of 138 items. During the analysis, 28 items were added based on suggestion of the experts. However, a total of 51 items were removed. This left a total of 115 items. These items were arrayed across four main dimensions of Leaders, Governors, Innovators, and Connectors. Additionally, a total of 21 sub-dimensions were used in this process. Most of the sub-dimensions identified had three items. However, there were several larger sub-dimensions, including policies and strategies (11 items), resource management (5 items), stakeholder engagement (5 items), vision (5 items), curriculum and teaching (10 items), and learning outcomes (7 items). These items and preliminary dimensional structure were used for the second stage of analysis.

Table 7 presents the Stage 1 outcome of the Delphi study. The Dimensions and Sub-Dimensions are identified for each dimension. This is followed by the total number of items assigned to each of the sub-dimensions. The Items column presents the items as they were phrased at the end of the Stage 1 instrument. This instrument was then used as the basis for the Stage 2 survey.

Table 7: Preliminary innovation ecosystem assessment framework as derived from the Delphi study (Stage 1)

Dimension	Sub Dimension	Total Items	Items
Leaders	Governance and culture (GC)	3	GC1. The university has a flexible organizational structure. GC2. The university's culture centralizes and prioritizes innovation and entrepreneurship. GC3. The university leadership actively promotes and supports innovation and entrepreneurship.
	Policies and Strategies (PS)	11	PS1. University policy is oriented to innovation and entrepreneurship. PS2. There is a high-level managerial commitment to implementing innovation and entrepreneurship policies in the university. PS3.There are clear policies to facilitate innovation in the university. PS4. There are clear policies to facilitate entrepreneurship in the university. PS5. There are clear policies to facilitate innovation and education entrepreneurship. PS6. The university's strategy includes innovation and entrepreneurship as central objectives. PS7. University strategies are oriented toward creating conditions for innovation (e.g., organizational connections, funding and support). PS8. The university works to influence national policy on university-based innovation and entrepreneurship. PS9. The university's short-term strategy addresses innovation processes (e.g., basic research and applications, networking activities). PS10. The university's short-term and medium-term strategies address innovation outcomes (e.g., patent issuance, licensing) PS11. University innovation strategy is routinely successful.

Dimension	Sub Dimension	Total Items	Items
	Resource management (LRM)	5	LRM1. University staffing is oriented toward innovation and entrepreneurship. LRM2. Academic and research staff are selected in part for their expertise in innovation and/or entrepreneurship in their areas of specialism. LRM3. The university budget includes adequate funding to support innovation and entrepreneurship. LRM4. The university has financial and technological resources available to facilitate innovation by students, early career researchers, and others without external or independent funding. LRM5. The university's resources are distributed fairly among innovation actors.
	Stakeholder engagement (SE)	5	SE1. Internal and external stakeholders in innovation activities are identified at the university level. SE2. Innovation at the university considers multiple stakeholders, including people and the environment. SE3. University innovation activities draw on a wide range of stakeholder perspectives. SE4. Stakeholders are consulted as appropriate depending on their interest in innovation. SE5. Stakeholder engagement can be considered successful.
	Vision (V)	5	V1. University vision is oriented to innovation and entrepreneurship. V2. University vision is clearly communicated in materials and policy. V3. University vision specifies purposes for innovation. V4. University vision considers innovation as a sustainable activity. V5. University vision for innovation is incorporated into policies and strategies.

Dimension	Sub Dimension	Total Items	Items
Educators	Curriculum and teaching (CT)	10	CT1. Educators have positive attitudes toward innovation. CT2. The university has an established teaching program for innovation and entrepreneurship studies. CT3. Principles of innovation and entrepreneurship are integrated into curriculum areas throughout the university. CT4. The university offers non-degree programs focused on innovation and entrepreneurship, like workshops, lectures and non-credit courses. CT5. The university offers various training programs for innovation and entrepreneurship, such as laboratory roles, internships and work experience. CT6. Innovation and entrepreneurship learning opportunities are available to all students, regardless of academic discipline. CT7. STEM degree courses place emphasis on innovation and entrepreneurship. CT8. Curriculum learning objectives include innovation knowledge. CT9. Continuing education in innovation is available for educators and staff members involved in teaching. CT10. The university is externally recognized as a center of innovation and entrepreneurship education.
	Industry involvement (II)	3	II1. Number of educator links with industry meets or exceeds targets. II2. Educators maintain knowledge and connections with industry through tools such as academic and professional conferences. II3. Educators are proactive at seeking industry support and connection.

Dimension	Sub Dimension	Total Items	Items
	Learning outcomes (LO)	7	LO1. Student enrolment in innovation courses meets or exceeds targets. LO2. Student satisfaction with innovation courses meets or exceeds targets. LO3. Graduation from innovation degree courses meets or exceeds targets. LO4. Student participation in innovation-oriented non-course learning, including laboratory research roles, work experience and internships, meets or exceeds targets. LO5. Student participation in non-course innovation and entrepreneurship activities, such as workshops and lectures, meets or exceeds targets. LO6. Student continuation in postgraduate innovation-oriented programs meets or exceeds targets. L07. Student intention to continue in innovation and entrepreneurship careers meets or exceeds targets.
Innovators	Production (IP)	3	IP1. Rate of scientific paper publication meets or exceeds targets. IP2. Rate of patent applications meets or exceeds targets. IP3. Rate of patent grants meets or exceeds targets.
	Commercialization (IC)	3	IC1. Sales of patents generated from innovative activities meets or exceeds targets. IC2. Licensing of patents generated from innovation activities meets or exceeds targets. IC3. Overall revenue from commercialization of innovation activities meets or exceeds targets.

Dimension	Sub Dimension	Total Items	Items
	Funding and Financial Management (FFM)	6	FFM1. Funding from private industry meets or exceeds targets. FFM2. Public funding meets or exceeds targets. FFM3. Private industry funding is available for innovation and research. FFM4. Public industry funding is available for innovation and research. FFM5. Overall funding for innovation and entrepreneurship activities is adequate. FFM6. Internal funding is distributed to facilitate innovation at all levels of the university.
	Incentive and Reward Systems (IRS)	3	IRS1. The university has reward systems that offer meaningful incentives for innovation and entrepreneurship. IRS2.The incentive and reward system rewards innovation and entrepreneurship at all levels of the organization. IRS3. The incentive and reward system rewards participation in innovation activities in all functional areas.
	Training and Mentoring (TM)	3	TM1. Training in innovation and entrepreneurship is available to students and researchers at all levels and disciplines. TM2. Participation in staff and student training programs meets or exceeds targets. TM3. Informal mentorship between researchers, academics and students are frequent.
	Role Models (RM)	3	RM1. Innovation and entrepreneurship role models are visible in the university. RM2. Innovation role models have external presence (e.g., external research and industry connections.) RM3. Students and early-career researchers have the opportunity to form relationships with researchers and innovators.

Dimension	Sub Dimension	Total Items	Items
	Business and Innovation Development (BID)	3	BID1. The number of start-ups and spin-offs created to develop and commercialize university innovation meets or exceeds targets. BID2. The university has a business innovation development program in place. BID3. The business innovation development program is broadly considered as successful.
	Faculty Involvement (FI)	3	FI1. The number of faculty engaged in research meets or exceeds targets. FI2. Faculty have opportunities to commercialize innovation activities. FI3. Faculty members are assessed on their participation in innovation and research as appropriate for specialty and position.
Connectors	External collaboration (EC)	3	EC1. Researchers and educators maintain links with colleagues at other institutions, private industry and other organizations. EC2. The university has short-term innovation partnerships with public and private organizations, including governments, NGOs, private industry, and local communications. EC3. The university has long-term innovation partnerships with public and private organizations, including governments, NGOs, private industry, and local communications.
	Internal collaboration (IC)	3	IC1. Researchers and educators across the university engage in cross-disciplinary cooperation. IC2. Administrators, governors, researchers, educators and students have access to networks of innovation activity. IC3. Internal collaborations result in substantial innovations.

Dimension	Sub Dimension	Total Items	Items
	Industry connections (ICO)	3	ICO1. The university has adequate links with industry. ICO2. University researchers and faculty members' rate of collaboration with research partners in industry meets or exceeds targets. ICO3. The university and its members participate in industry-wide innovation development activities as appropriate.
	Entrepreneurial Education (EE)	3	EE1. The number of courses addressing entrepreneurship meets or exceeds targets. EE2. The university has an established innovation and entrepreneurship educational track or program at the undergraduate level. EE3. The university has an established innovation and entrepreneurship educational track or program at the postgraduate level.
	Entrepreneurial Hub (EH)	3	EH1. The university has a centralized office or hub for innovation and entrepreneurship coordination. EH2. The innovation office or innovation hub is appropriately funded for the university's innovation activities. EH3. The innovation office or innovation hub serves as a coordination point for engagement with external partners, including government agencies, NGOs, private industry, and academics at other universities to facilitate innovation.

4.2 Stage 2: Expert Survey

Stage 2 of the research was an expert survey, which was dedicated to refining and if necessary, reducing the measurement model that was initially developed during Stage 1. The analysis for this stage was conducted using Confirmatory Factor Analysis (CFA). Here, a brief overview of the participants is provided. This is then followed by presentation of the CFA results from each of the four constructs: Leaders and Governors, Educators, Innovators and Connectors. Although Agents of Change was proposed in the conceptual framework, this element was eliminated entirely in Stage 1 and therefore it was not investigated.

4.2.1 Participant profile

A total of 418 participants were recruited for the Stage 2 expert survey. These participants came only from the ASEAN countries but included a range of roles and participants. Participants had an average of 12.9 years' experience specifically in university innovation systems and practices, compared to an average of 20.1 years' work experience overall. Almost all participants were educated to at least the Master's level (97.1%) and the remainder held other terminal degrees as appropriate for their field. Thus, this can be considered an experienced expert sample.

Country and role descriptive statistics are summarized in Table 8. As this shows, the largest group of participants came from Thailand (40.9%). The sample was selected to ensure at least 20 participants from each country, but because the researcher's own university and connections were used to seed the initial sample, Thailand's representation is slightly above what would be expected from a study conducted in ASEAN. Other countries represented in the study by the sub-sample size included Singapore (10.5%), Malaysia (9.3%), Indonesia (8.4%), Philippines (6.7%), Myanmar (5.0%), and Brunei, Cambodia, Laos, and Vietnam (4.8% each). While not exactly consistent with the country characteristics, this is a rough correspondence between country size and/or number of research universities.

By general role, the largest groups included researchers (21.5%) and educators (16.3%). This was not unexpected, given that these participants could be expected to be both the most numerous and the most directly interested in university innovation. Other groups in the sample included innovation policymakers (12.5%), third-sector innovation partners (11.7%), private-sector innovation partners (11.5%), university leaders (11.2%), innovation coordinators (9.3%), and public-sector innovation partners (6%). Therefore, there were a wide range of stakeholder groups represented in the survey.

Table 8 Descriptive statistics of the expert survey sample (Stage 2)

Country	Participants	% Of Sample
Brunei Darussalam	20	4.8
Cambodia	20	4.8
Indonesia	35	8.4
Laos	20	4.8
Malaysia	39	9.3
Myanmar	21	5.0
Philippines	28	6.7
Singapore	44	10.5
Thailand	171	40.9
Vietnam	20	4.8

Expert Role	Participants	% Of Sample
University leaders	47	11.2
Innovation policymakers	52	12.4
Educators	68	16.3
Researchers	90	21.5
Innovation coordinators	39	9.3
Private-sector innovation partners	48	11.5
Public-sector innovation partners	25	6.0
Third-sector innovation partners	49	11.7

4.2.2 Reliability, validity and goodness of fit

The first stage of research involved investigating the construct reliability and goodness of fit for each of the four measurement models that were subjected to analysis using CFA.

Reliability and validity. Table 9 summarizes the construct reliability and validity statistics. Reliability is assessed using CR (>.70) (Fornell and Larcker, 1981; Hair et al., 2016). All measures pass this test, indicating overall reliability of the scales is adequate. Convergent validity was assessed using CR (> .70) and AVE (>.50) (Fornell and Larcker, 1981; Hair et al., 2016). Most measures also passed this threshold. The final measure was discriminant validity (MSV < AVE) (Fornell and Larcker, 1981; Hair et al., 2016). There were a few scales that did not meet these criteria. The researcher then faced a choice about whether to adjust the scales to improve fit or to continue. Given that the intention of the analysis was scale development and items would be removed, presumably to improve fit, there were no adjustments made at this time. However, these items were noted as possible issues to be considered in the model fitting process.

Table 9 Reliability and validity measures: Stage 2 measurement models

Model	Construct	CR	AVE	MSV
Leaders and Governors	Vision (V)	.821	.628	.606
	Policies and Strategies (PS)	.728	.692	.684
	Governance and Culture (GC)	.716	.495	.502
	Resource Management (LRM)	.782	.508	.441
	Stakeholder Engagement (SE)	.735	.682	.582
Educators	Curriculum and Teaching (CT)	.734	.591	.518
	Learning Outcomes (LO)	.802	.752	.594
	Industry Involvement (II)	.702	.685	.583
Innovators	Production (IP)	.791	.692	.629
	Commercialization (IC)	.802	.644	.596
	Funding and Financial Management (FFM)	.816	.791	.782
	Incentive and Reward Systems (IRS)	.872	.736	.678
	Training and Mentoring (TM)	.773	.602	.581

Model	Construct	CR	AVE	MSV
	Role Models (RM)	.767	.586	.582
	Business Innovation Development (BID)	.752	.566	.505
	Faculty Involvement (FI)	.771	.687	.590
Connectors	External Collaboration (EC)	.862	.784	.772
	Internal Collaboration INTC)	.701	.708	.603
	Industry Connections (ICO)	.777	.683	.681
	Entrepreneurial Education (EE)	.701	.491	.490
	Entrepreneurial Hub (EH)	.778	.591	.695

Note: Required levels include CR (> .70), AVE (> .5) MSV (< AVE)
(Fornell and Larcker, 1981; Hair et al., 2016)

Goodness of fit. Table 10 summarizes goodness of fit measures for all four of the measurement models. The Leaders and Governors model (CFI = .938, TLI = .922, RMSEA = .054) met or exceeded all requirements for a well-fitted model. The Educators model met the CFI and TLI requirements but was a little poorly fitted according to RMSEA (CFI = .939, TLI = .908, RMSEA = .067). This was investigated further, and it was found that there was actually a lot of disagreement about appropriate cut-offs for RMSEA, with some authors suggesting up to .10 is acceptable fit (Kenny, Kaniskan and McCoach, 2015). Since the other two measures of fit showed adequate fit, this measure was left in place. The Innovators model was acceptable according to CFI and RMSEA but was slightly under the minimum threshold for TLI (CFI = .916, TLI = .893, RMSEA = .054). The researcher also chose not to try to realign this model for better fit since it was acceptably fitted according to two measures. The final model, Connectors, was adequately fitted according to all measures (CFA = .953, TLI = .929, RMSEA = .047). Therefore, no adjustments were made at this stage of the study.

Table 10 Goodness of fit measures: Stage 2 measurement models

Model	CFI	TLI	RMSEA
Leaders and Governors	.938	.922	.054
Educators	.939	.908	.067
Innovators	.916	.893	.054
Connectors	.953	.929	.047

Note: required levels include CFI (>.90). TLI (>.90), and RMSEA (<.06)

(Hu and Bentler, 1999; Kenny, Kaniskan and McCoach, 2015)

4.2.3 Measurement models

There were four separate measurement models, one for each of the lead dimensions of university innovation ecosystems (Leaders and Governors, Educators, Innovators, and Connectors). The graphical image of each of these measurement models are shown in Figures 12 (Leaders and Governors), 13 (Educators), 14 (Innovators) and 15 (Connectors). These measurement models show the factor loadings for the individual items that measured each of the first-order constructs that were used within the overall model after the model reduction processes.

Each of the CFA models consists of a three-part measure, with the first-order constructs (individual items) reflecting second-order dimensions, which are then loaded onto an overall dimension. For example, in the Leaders and Governors (LG) construct, shown in Figure 12, there were a total of 15 items, loaded onto five second-order constructs after the model reduction process, which eliminated any items with a factor loading of < .60. The same structure is reflected throughout the other four models. The goodness of fit measures for these measurement models (Table 10) were adequate based on the measures included. Therefore, these were considered as appropriate for use as the final measures at this stage of the research.

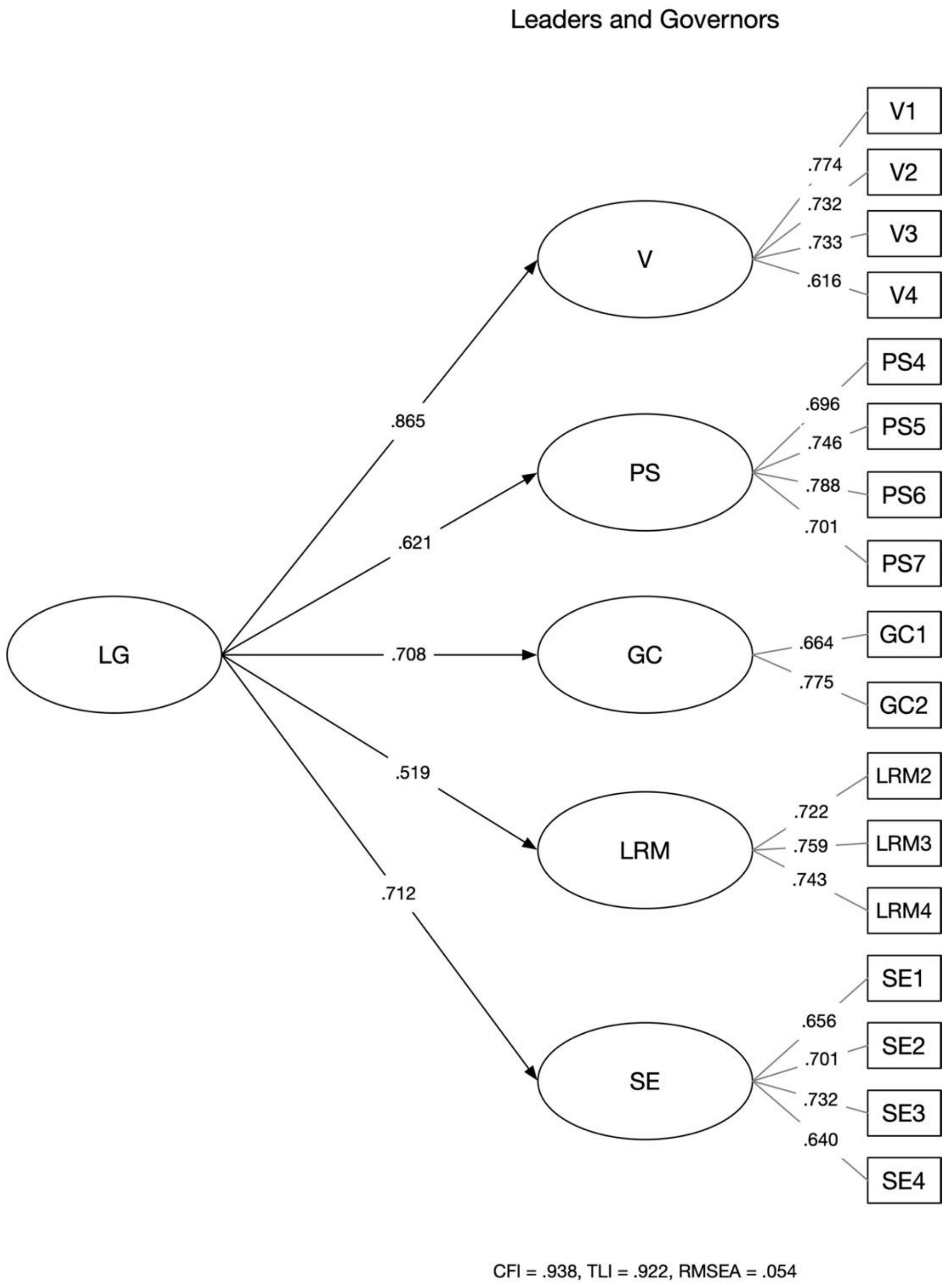


Figure 12 Confirmatory factor analysis (Stage 2): Measurement model for Leaders and Governors

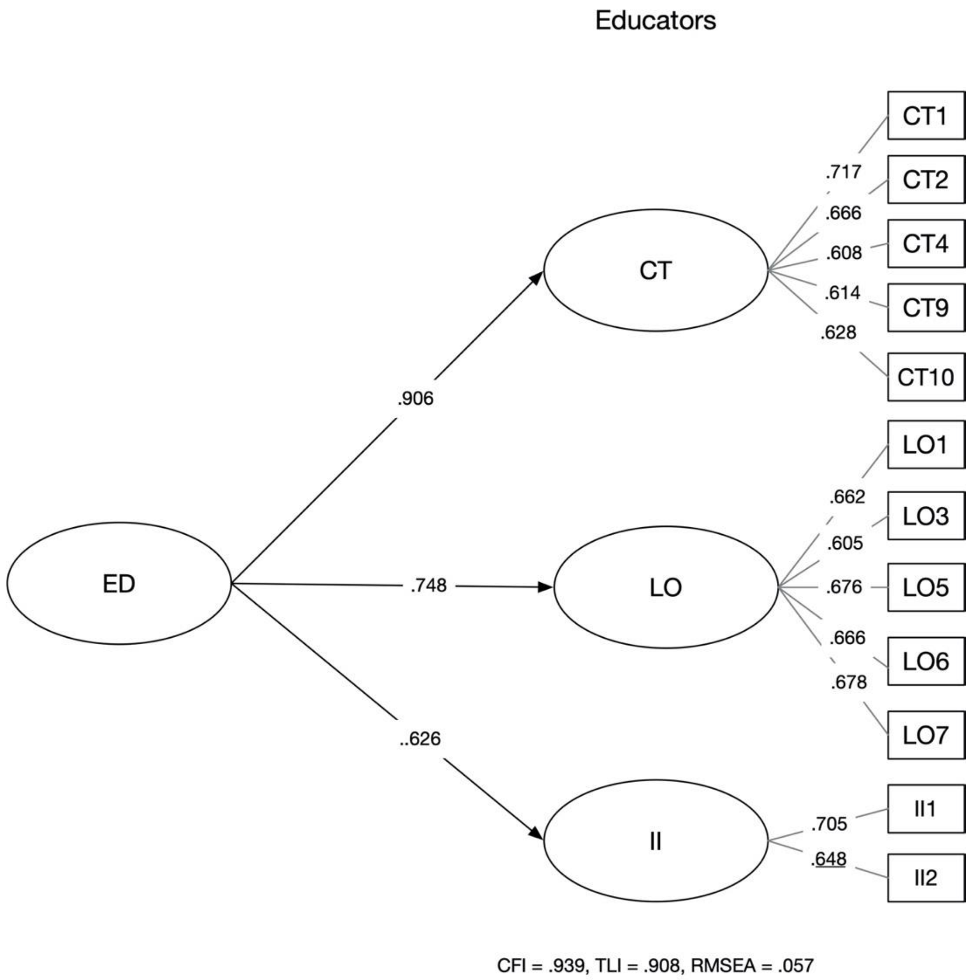


Figure 13 Confirmatory factor analysis (Stage 2): Measurement model for Educators

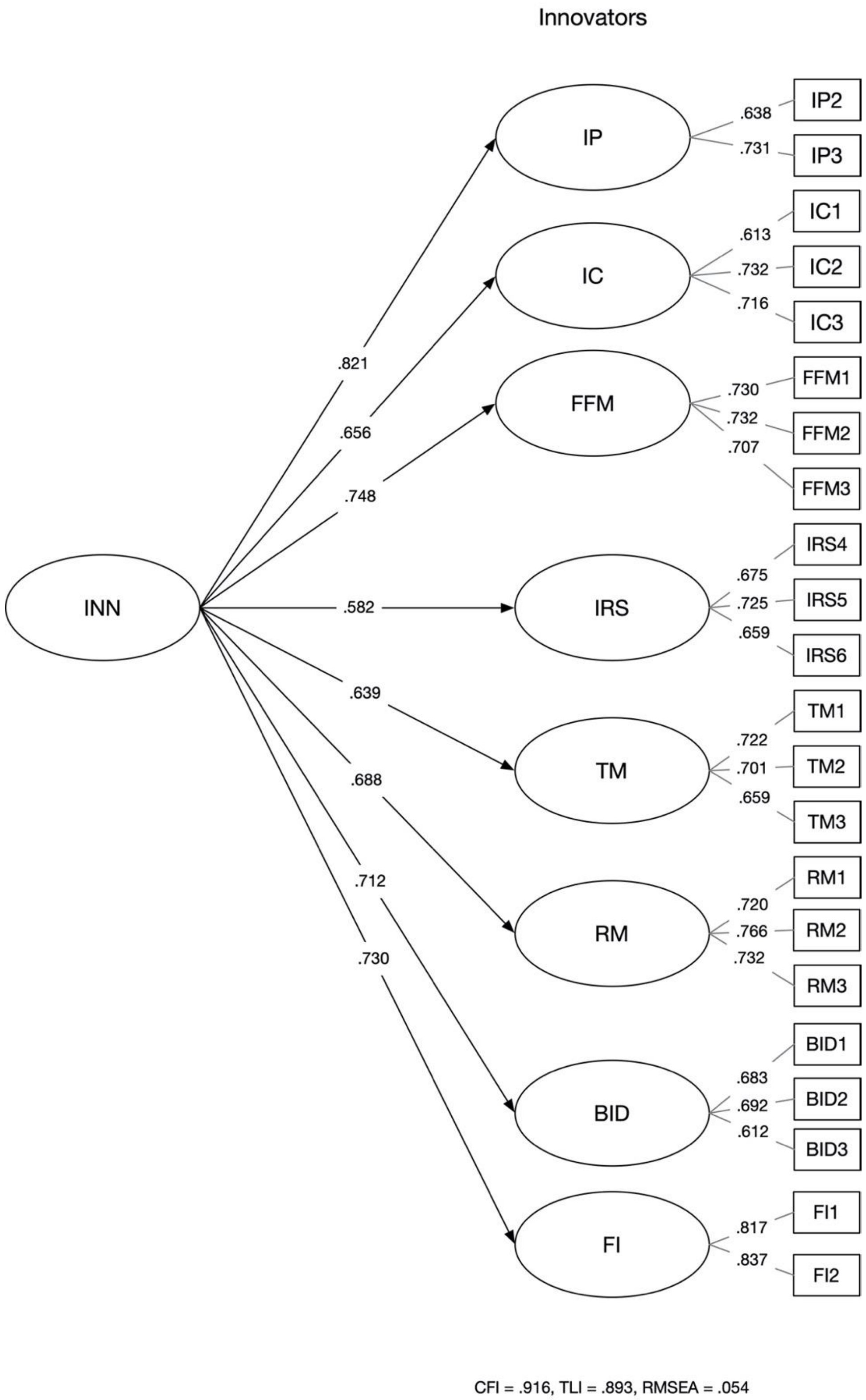


Figure 14 Confirmatory factor analysis (Stage 2): Measurement model for Innovators

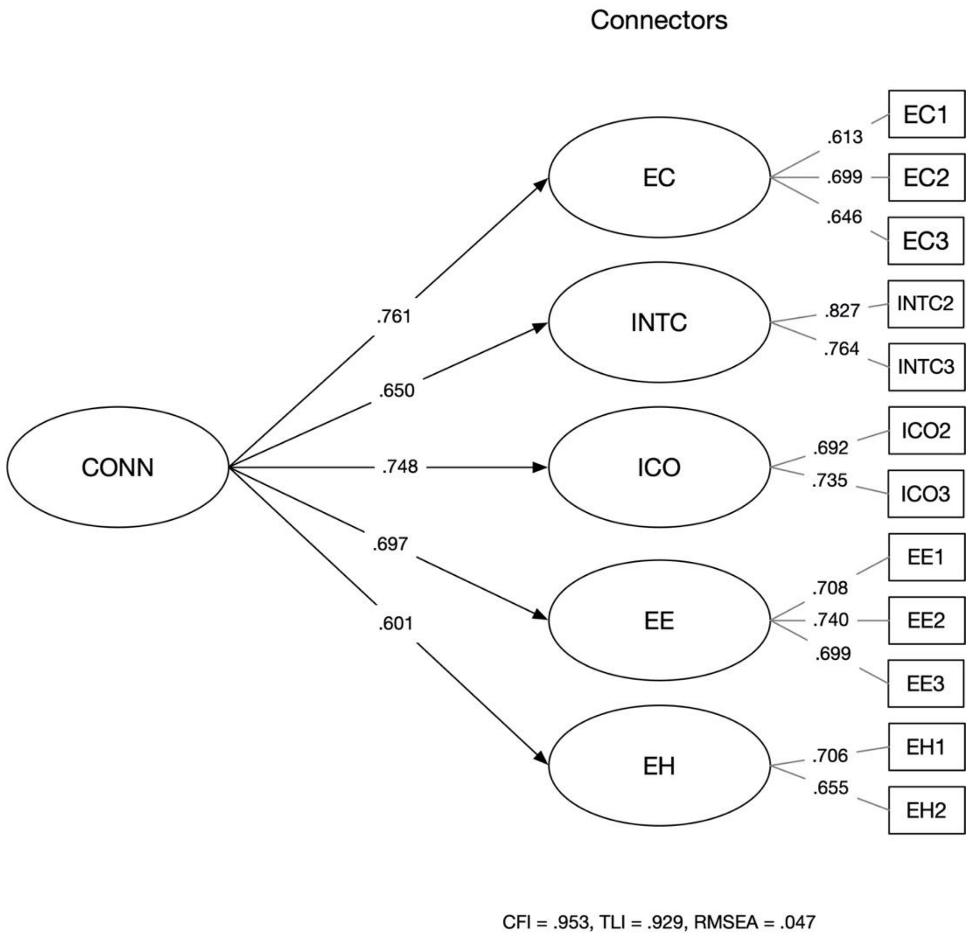


Figure 15 Confirmatory factor analysis (Stage 2): Measurement model for Connectors

The model reduction process involved removal of poorly correlated or unrelated items from the proposed scales, based on the factor loading (Brown, 2015). A factor loading of at least .60 was required to include the item within the scale. Table 11 summarizes the factor loadings for each of the individual items and their assignment to scales. None of the items were moved between scales. However, a total of 29 items was removed from their assigned scales due to low factor loadings. Thus, the refined instrument used for nomological testing in Stage 3 consisted of 64 items.

Cronbach's alpha was used as a final check on the internal consistency of the individual measures. A minimum value of .600 was considered to be acceptable as an alpha value, given that this was a developmental process (Krosnick and Presser, 2010). Most of the measures reached this required level; however, EH (α = .596) was close to, but below, this threshold. Thus, most of the measures developed from this process display adequate internal consistency, but some did not reach this level. As discussed later in the research, this is an opportunity for further study.

Table 11 summarizes the results of the CFA process for Stage 2. Each of the Models was represented by several different Constructs, corresponding to the primary dimensions and sub-dimensions of the conceptual model respectively. For example, the Leaders and Governors model includes constructs of Vision (V), Policies and Strategies (PS), Governance and Culture (GC), Resource Management (LRM), and Stakeholder Engagement (SE). The number of total items initially loaded onto the construct is presented in the third column. For example, the Vision construct initially had five items. The fourth column represents the Cronbach's alpha score of the initial model; for example, Vision's alpha score was 0.808. In the fourth column, the initial factor loadings for each of the individual items in the construct is presented. Each of the constructs underwent a process of model reduction to remove the poorly related items (<.60 factor loading) (Brown, 2015). This typically resulted in higher factor loadings, but fewer items, as summarized in the last column. For example, in Vision, item V5 was removed, resulting in higher factor loadings for most items.

Table 11 Confirmatory factor analysis (Stage 2): Factor loadings for initial and final model

Model	Construct	Items	□	Items	Initial Model Factor Loading	Final Model Factor Loading
Leaders and Governors	Vision (V)	5	.808	V1	.758	.774
				V2	.697	.732
				V3	.731	.733
				V4	.650	.616
				V5	.557*	.
	Policies and Strategies (PS)	11	.841	PS1	.432*	.
				PS2	.434*	.
				PS3	.424*	.
				PS4	.643	.696
				PS5	.674	.746
				PS6	.757	.788

Model	Construct	Items	□	Items	Initial Model Factor Loading	Final Model Factor Loading
				PS7	.650	.701
				PS8	.557*	.
				PS9	.570*	.
				PS10	.502*	.
				PS11	.573*	.
	Governance and Culture (GC)	3	.682	GC1	.630	.664
				GC2	.772	.775
				GC3	.566*	.
	Resource Management (LRM)	5	.782	LRM1	.569*	.
				LRM2	.682	.722
				LRM3	.727	.759
				LRM4	.721	.743
				LRM5	.570*	.
	Stakeholder Engagement (SE)	5	.782	SE1	.636	.656
				SE2	.684	.701
				SE3	.692	.732
				SE4	.649	.640
				SE5	.592*	.

Model	Construct	Items	□	Items	Initial Model Factor Loading	Final Model Factor Loading
Educators	Curriculum and Teaching (CT)	10	.857	CT1	.649	.717
				CT2	.650	.666
				CT3	.583*	.
				CT4	.631	.608
				CT5	.571*	.
				CT6	.579*	.
				CT7	.574*	.
				CT8	.589*	.
				CT9	.609	.614
				CT10	.676	.682
	Learning Outcomes (LO)	7	.808	LO1	.619	.662
				LO2	.562*	.
				LO3	.640	.605
				LO4	.580*	.
				LO5	.647	.676
				LO6	.648	.666
				LO7	.603	.678

Model	Construct	Items	□	Items	Initial Model Factor Loading	Final Model Factor Loading
	Industry Involvement (II)	3	.643	II1	.651	.705
				II2	.622	.648
				II3	.572*	.
Innovators	Innovation Production (IP)	3	.630	IP1	.545*	.
				IP2	.600	.638
				IP3	.682	.731
	Innovation Commercialization (IC)	3	.722	IC1	.609	.613
				IC2	.732	.732
				IC3	.721	.716
	Funding and Financial Management (FFM)	3	.764	FFM1	.730	.730
				FFM2	.726	.732
				FFM3	.712	.707
	Incentive and Reward Systems (IRS)	6	.792	IRS1	.503*	.
				IRS2	.601	.
				IRS3	.605	.
				IRS4	.619	.675
				IRS5	.654	.725
				IRS6	.658	.659

Model	Construct	Items	□	Items	Initial Model Factor Loading	Final Model Factor Loading
				IRS7	.526*	.
	Training and Mentoring (TM)	3	.721	TM1	.633	.722
				TM2	.707	.701
				TM3	.713	.727
	Role Models (RM)	3	.738	RM1	.712	.720
				RM2	.769	.766
				RM3	.637	.732
	Business and Innovation Development (BID)	3	.696	BID1	.677	.683
				BID2	.691	.692
				BID3	.618	.612
	Faculty Involvement (FI)	3	.780	FI1	.747	.817
				FI2	.914	.837
				FI3	.585*	.
Connectors	External Collaboration (EC)	3	.688	EC1	.602	.613
				EC2	.685	.699
				EC3	.667	.646

Model	Construct	Items	□	Items	Initial Model Factor Loading	Final Model Factor Loading
	Internal Collaboration (IC)	3	.706	INTC1	.567	.
				INTC2	.798	.827
				INTC3	.724	.764
	Industry Connections (ICO)	3	.675	ICO1	.549*	.
				ICO2	.675	.692
				ICO3	.717	.735
	Entrepreneurial Education (EE)	3	.758	EE1	.724	.708
				EE2	.742	.740
				EE3	.682	.699
	Entrepreneurial Hub (EH)	3	.596	EH1	.636	.706
				EH2	.639	.655
				EH3	.446*	.

Note: * factor loading < .60, item eliminated during final round

4.3 Stage 3: Nomological Testing

The nomological testing used the refined model (developed in Stage 2) in a broader sample of experts across the Asia Pacific region, in order to test the internal structure of the refined model in a separate sample. Here, the participant profile, reliability and validity, and measurement models are discussed.

4.3.1 Participant profile

A total of 459 experts participated in the third round expert survey. Home countries and expert roles are summarized in Table 12. This shows participants came from 16 countries, with the largest groups coming from Thailand (18.5%) and China (13.5%). Overall, ASEAN accounted for 54.9% of the sample in this group, indicating a broader sample than the Stage 2 survey. In terms of innovation role, Researchers (18.7%) and educators (14.8%) were still the largest individual groups, but other roles accounted for 15% of the sample. Thus, the sample was somewhat different from the initial sample.

Table 12 Summary of respondent profiles: Stage 3

Country	Participants	% Of Sample
Brunei Darussalam	12	2.6
Cambodia	13	2.8
Indonesia	25	5.4
Laos	11	2.4

Country	Participants	% Of Sample
Malaysia	19	4.1
Myanmar	7	1.5
Philippines	24	5.2
Singapore	35	7.6
Thailand	85	18.5
Vietnam	21	4.6
Australia	31	6.8
China	62	13.5
Japan	29	6.3
South Korea	38	8.3
India	14	3.1
Other Countries	33	7.2

Expert Role	Participants	% Of Sample
University leaders	39	8.5

Country	Participants	% Of Sample
Innovation policymakers	41	8.9
Educators	68	14.8
Researchers	86	18.7
Innovation coordinators	39	8.5
Private-sector innovation partners	48	10.5
Public-sector innovation partners	35	7.6
Third-sector innovation partners	34	7.4
Other Roles	69	15.0

4.3.2 Reliability, validity and goodness of fit

Reliability and validity measures for the Stage 3 analysis are provided in Table 13. This shows that for most of the variables, reliability and validity was slightly improved in Stage 3, which was expected given the model reduction process that was conducted following Stage 1. All variables met the established criteria for CR (> .70), AVE (>.50) and MSV (<. AVE). This indicates that the model variables display adequate levels of reliability and convergent and discriminant validity. Furthermore, removal of items improved the reliability and validity of many of the marginal items.

Thus, the initial assessment shows that the reliability and validity of the model were improved compared to the Stage 2 test of the preliminary model.

Table 13 Reliability and validity measures: Stage 3

Model	Construct	CR	AVE	MSV
Leaders and Governors	Vision (V)	.822	.632	.612
	Policies and Strategies (PS)	.728	.682	.680
	Governance and Culture (GC)	.719	.543	.512
	Resource Management (LRM)	.785	.512	.502
	Stakeholder Engagement (SE)	.740	.693	.580
Educators	Curriculum and Teaching (CT)	.746	.601	.515
	Learning Outcomes (LO)	.813	.755	.590
	Industry Involvement (II)	.731	.687	.580
Innovators	Production (IP)	.792	.691	.618
	Commercialization (IC)	.803	.649	.584
	Funding and Financial Management (FFM)	.821	.790	.743
	Incentive and Reward Systems (IRS)	.894	.740	.699
	Training and Mentoring (TM)	.783	.592	.580
	Role Models (RM)	.756	.596	.564

Model	Construct	CR	AVE	MSV
	Business Innovation Development (BID)	.762	.570	.526
	Faculty Involvement (FI)	.782	.689	.601
Connectors	External Collaboration (EC)	.876	.785	.776
	Internal Collaboration INTC)	.703	.718	.721
	Industry Connections (ICO)	.769	.685	.685
	Entrepreneurial Education (EE)	.712	.512	.494
	Entrepreneurial Hub (EH)	.769	.593	.501
Note: Required levels include CR (> .70), AVE (> .5) MSV (< AVE) (Fornell and Larcker, 1981; Hair et al., 2016)				

Goodness of fit measures for the Stage 3 models are summarized in Table 14. These goodness of fit measures indicate that all four measures are adequately fitted based on the established criteria. The thresholds included CFI >.90 (Hu and Bentler, 1999), TLI > .90 (West, Taylor and Wu, 2012), and RMSEA < .06 (Kenny, Kaniskan and McCoach, 2015) It can be seen that the lowest CFI was for Innovators (CFI = 0.919), which was above the threshold. The TLI of Innovators (TLI = .899) was very slightly below the threshold, but this was too small a difference to adjust through model adjustment. All of the measures were below the RMSEA threshold, with Educators (RMSEA = 0.54) having the highest score. Overall, this indicates all measures were adequate based on the selected thresholds. Therefore, the analysis continuedใ

Table 14 Goodness of fit measures: Stage 3 measurement models

Model	CFI	TLI	RMSEA
Leaders and Governors	.951	.933	.049
Educators	.942	.911	.054
Innovators	.919	.899	.051
Connectors	.951	.933	.049

Note: required levels include CFI (>.90). TLI (>.90), and RMSEA (<.06) (Hu and Bentler, 1999; West, Taylor and Wu, 2012; Kenny, Kaniskan and McCoach, 2015)

4.3.3 Measurement models and internal correlations

The first purpose of the nomological validity testing was to investigate the characteristics of the measurement model and examine the relationships of the first-order constructs and second-order constructs. Each of the individual models are discussed in brief below.

4.3.3.1 Nomological validity of Leaders and Governors

Figure 16 shows the nomological validity test for Leaders and Governors. The internal relationships of second-order constructs (V, PS, GC, LRM and SE) and LG, as well as the internal relationships between the constructs, are summarized in Table 15. As this shows, the relationships of the first-order constructs to the second-order construct (LG) are all relatively strong, with the weakest observed relationship being SE-LG (.604). This indicates that overall, the first-order constructs are reflecting the second-order construct adequately. However, there are some weak internal relationships between the first-order constructs, particularly the PS-SE and LRM-SE relationships, where factor loadings were below .50. Thus, not all of the Leaders and Governors first-order constructs are strongly related to each other. Overall, this model does therefore show nomological validity, but it is possible that this could potentially better be represented by two separate constructs. This could not be resolved within the bounds of the current study, but it is identified as an opportunity for further research.

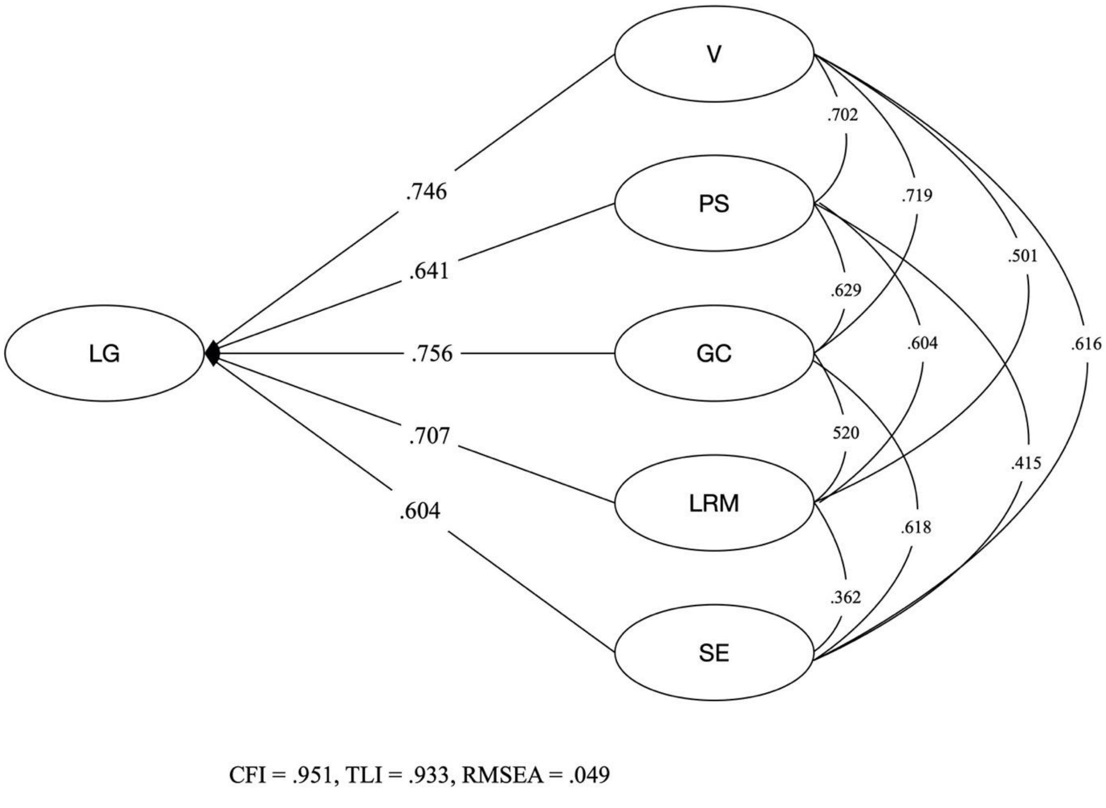


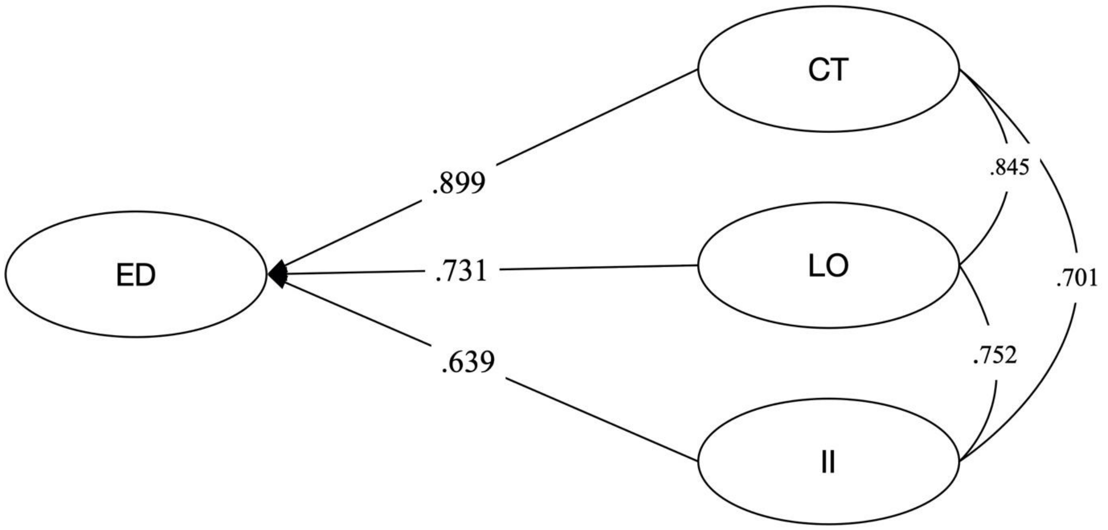
Figure 16 Nomological validity test (Stage 3): Leaders and Governors

Table 15 Internal correlations of Leaders and Governors constructs (path coefficients)

	V	PS	GC	LRM	SE
LG	.832	.619	.756	.521	.714
V		.702	.719	.501	.616
PS			.518	.604	.415
GC				.520	.618
LRM					.362

4.3.3.2 Nomological validity of Educators

The Educators construct (Figure 17) included three first-order constructs – CT, LO and II. As shown in Table 16, these measures are all relatively strongly associated with the second-order construct ED, with factor loadings between .639 and .899. The first-order constructs are also relatively strongly associated with each other as well, reinforcing the internal relationship structure of the model. Overall, this is clear that the model's first-order constructs are representing a single underlying dimension (Educators).



CFI = .942, TLI = .911, RMSEA = .054

Figure 17 Nomological validity test (Stage 3): Educators

Table 16 Internal correlations of Educators constructs (path coefficients)

	CT	LO	II
ED	.899	.731	.639
CT		.845	.752
LO			.701

4.3.3.3 Nomological validity of Innovators

The Innovators model (Figure 18) included the most second-order constructs of any of the models (IP, ICO, FFM, IRS, TM, RM, BID and FI). This is unsurprising given that innovation is the central area of concern and in some ways the most complex problem. The path coefficients (Table 17) indicate that the overall relationships of the second-order construct INN and its first-order constructs is moderate to strong, with path coefficients ranging from .602 to .809. However, the internal relationships of the first-order constructs are in many cases quite weak, with path coefficients of .300 or lower. This suggests that it is possible that a better representation would be to divide Innovation into two different second-order constructs, which could be called Innovation Activity (IP, ICO, and FFM) Innovation Policy (including IRS, TM, RM, BID and FI). This opportunity is identified in the following chapter as an opportunity for additional research.

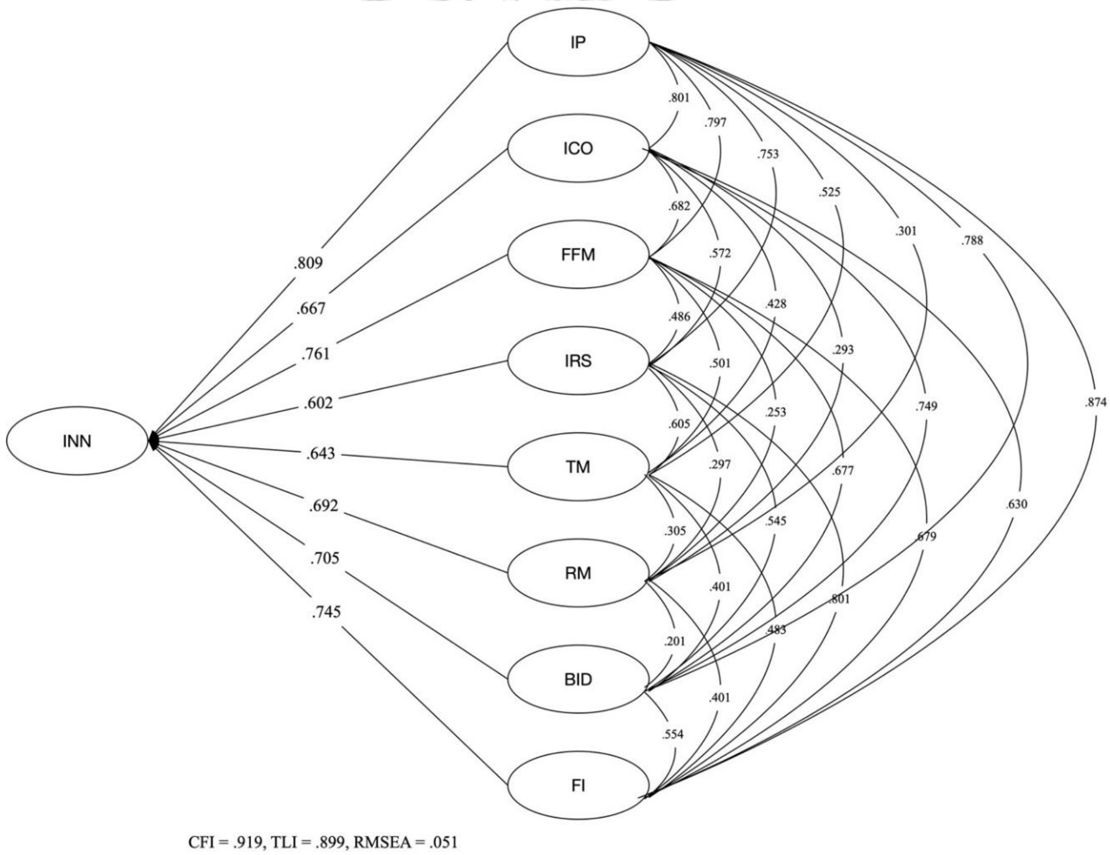


Figure 18 Nomological validity test (Stage 3): Innovators

Table 17 Internal correlations of Innovators constructs (path coefficients)

Path Coefficients	IP	ICO	FFM	IRS	TM	RM	BID	FI
INN	.809	.667	.761	.602	.643	.692	.705	.745
IP		.801	.797	.753	.525	.301	.788	.874
ICO			.682	.572	.428	.293	.749	.630
FFM				.486	.501	.253	.677	.679
IRS					.605	.297	.545	.801
TM						.305	.401	.483
RM							.201	.401
BID								.554

4.3.3.4 Nomological validity of Connectors

The final test for nomological validity was for the Connectors model, which is shown in Figure 19, with internal path coefficients summarized in Table 18. The association of the first-order constructs (EC, INTC, ICO, EE and EH) to the second-order construct CONN was adequate, with factor loadings of .604 to .756. These are not as high as some of the other observed models, suggesting there is still some weakness in the representation of Connectors. Overall, the internal relationships of the first-order constructs were only moderately strong. In this case, EC, INTC and ICO are relatively strongly associated with each other (>.60). However, EE is only strongly associated with INTC (.717) and EH, while adequately associated with CONN, is only weakly associated with the other first-order constructs. This could mean that EH should be placed in another component, possibly the Innovation Policy component proposed in the previous section. Overall, this model indicates that while Connectors has adequate construct validity, it could potentially be better.

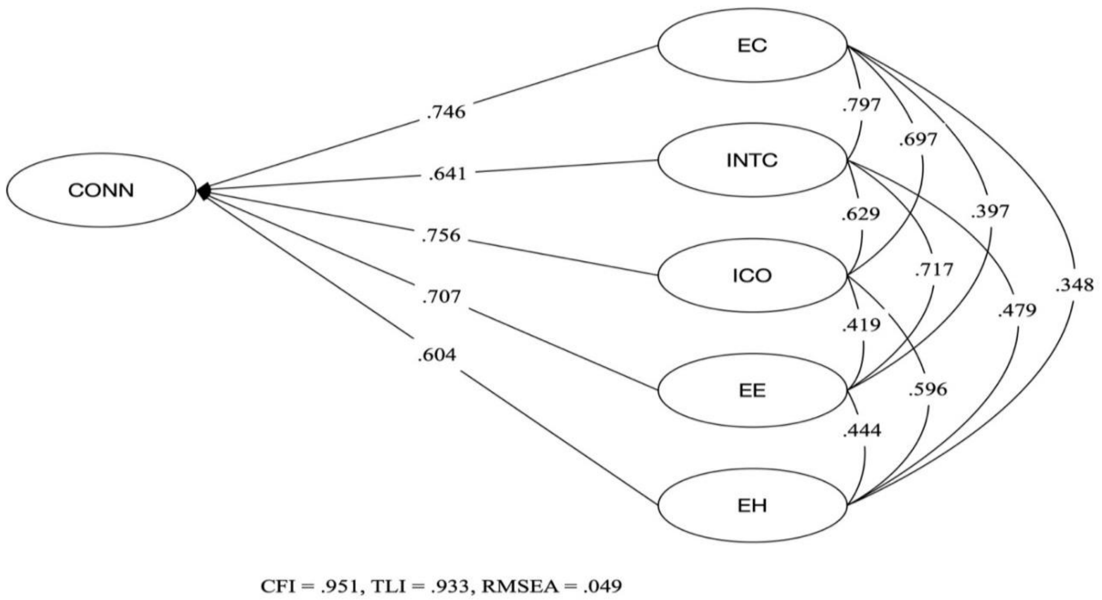


Figure 19 Nomological validity test (Stage 3): Connectors

Table 18 Internal correlations of Connectors constructs (path coefficients)

Path Coefficients	EC	INTC	ICO	EE	EH
CONN	.746	.641	.756	.707	.604
EC		.797	.697	.397	.348
INTC			.629	.717	.479
ICO				.418	.596
EE					.444

4.3.4 Comparison of Stage 2 and Stage 3 Models

The final aspect of the nomological validity testing was to examine the performance of the refined model derived from Stage 2 to its Stage 3 application. The purpose of this comparison is to understand the degree of the final instrument's generalizability between samples. While these are not expected to be exactly the same between samples, they should be similar; otherwise, this indicates the model may not be fully reliable (Liu, Li and Zhu, 2012). Note that the samples for Stage 2 and Stage 3 of the study were not the same, as the purpose of nomological testing is to compare results across different samples (Liu, Li and Zhu, 2012). Although some participants were likely included in both samples (due to the relatively small potential population and the recruitment techniques, this information was not tracked. Therefore, a direct comparison is not possible.

The path coefficients for the first-order constructs and their association with the second-order construct are used here for comparison in Table 19. Most of the constructs showed little movement between the two models, but there were a few that changed by more than .05 (indicating a more than 5% change in the factor loading). These included several first-order constructs of Leaders and Governors (Vision, Resource Management, and Stakeholder Engagement). None of the other constructs shifted much, but the Leaders and Governors measure appeared to be unstable. Potential reasons for this are discussed in the next section.

Table 19 Comparison of Stage 2 and Stage 3 factor loadings

Second Order Construct	First Order Construct	Factor Loadings	
		Stage 2	Stage 3
Leaders and Governors	Vision (V)	.865	.746
	Policies and Strategies (PS)	.621	.641
	Governance and Culture (GC)	.708	.756
	Resource Management (LRM)	.519	.707
	Stakeholder Engagement (SE)	.712	.604
Educators	Curriculum and Teaching (CT)	.906	.899
	Learning Outcomes (LO)	.748	.731
	Industry Involvement (II)	.626	.639
Innovators	Production (IP)	.821	.809
	Commercialization (IC)	.656	.667
	Funding and Financial Management (FFM)	.748	.761
	Incentive and Reward Systems (IRS)	.582	.602
	Training and Mentoring (TM)	.639	.643

Second Order Construct	First Order Construct	Factor Loadings	
		Stage 2	Stage 3
	Role Models (RM)	.688	.692
	Business Innovation Development (BID)	.712	.705
	Faculty Involvement (FI)	.730	.745
Connectors	External Collaboration (EC)	.761	.756
	Internal Collaboration INTC)	.650	.641
	Industry Connections (ICO)	.748	.756
	Entrepreneurial Education (EE)	.697	.707
	Entrepreneurial Hub (EH)	.601	.604

The hypotheses of the study were mostly, but not entirely, supported. There were several different aspects of the Leaders and Governors construct that were relevant to the university innovation ecosystem, its formation and its development. The university's Vision, its Policies and Strategies, its Governance and Culture, and practices of Resource Management and Stakeholder Engagement all had an effect on the formation of the university innovation ecosystem. Therefore, with regard to

Hypothesis 1, Leaders and Governors did influence the university innovation ecosystem.

In terms of Educators, Curriculum and Teaching was the most important aspect of the dimensions. Student Learning Outcomes were also relevant, as these represented how students were being prepared for participation in innovation activities. Furthermore, the Industry Involvement of Educators was an important aspect in this dimension. Thus, with regard to Hypothesis 2, Educators also influenced the university innovation ecosystem.

The Innovators dimension was diverse, as it included several structures, processes, and policies that influenced the university innovation ecosystem. Innovation activity itself, including Production and Commercialization, was the starting point for Innovators. Support processes, including Funding and Financial Management, Incentive and Reward Systems, and Business Innovation Development, were also key to the university innovation ecosystem. There was also an educational and training aspect to the Innovators dimension, as processes of Training and Mentoring, serving as Role Models, and the presence of Faculty Involvement in innovation all affected the formation of the university innovation ecosystem. In response to Hypothesis 3, Researchers of course influenced the university innovation ecosystem.

There were also several processes of the university innovation ecosystem in which the role of Connectors were key. External Collaboration and Internal Collaboration were drivers of innovation. These collaboration activities were facilitated by Industry Connections. Furthermore, Entrepreneurial Education activities and the institutional presence of an Entrepreneurial Hub served to both develop innovation activities and to connect researchers with others who could foster innovation and provide resources. Thus, as far as Hypothesis 4, Connectors were also an influential part of the university innovation ecosystem.

Although it was initially identified as present based on prior studies, the Delphi study outcomes indicated that the Agents of Change dimensions that had been identified were redundant, given that promoting and managing change was inherent in other roles. Therefore, the Agents of Change dimension was eliminated from the university innovation ecosystem at an early stage of the study. As a result, Agents of Change were not a significant part of the university innovation ecosystem, and Hypothesis 5 was not supported.

The finalized model is presented in Figure 20. This finalized model identifies the four core dimensions of the university innovation ecosystem (Leaders and Governors, Educators, Innovators and Connectors) and their sub-dimensions that are used to measure. The items used to measure the test are summarized in the sections above.

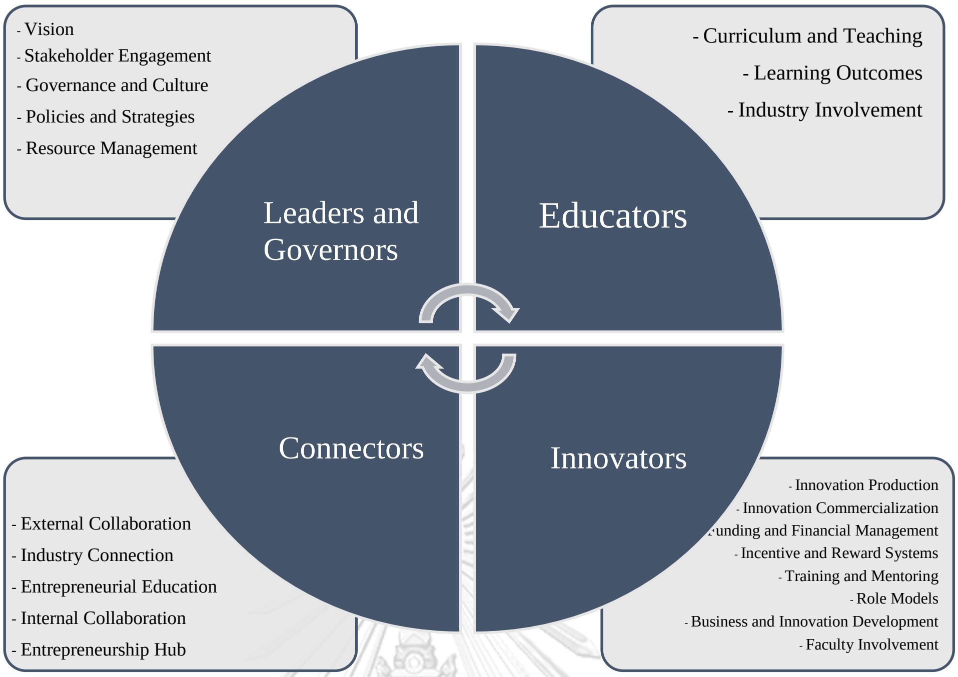


Figure 20 The finalized ASEAN University Innovation Ecosystem Assessment (AUIEA) model

4.4 Validating the AIUEA Model With Case Studies

The final stage of the research was validation of the AIUEA model through application to real-world universities. In order to test the model in application, first an assessment rubric was created using the CMMI framework (Constantinescu and Iacob, 2007; Paulk, 2009; Duarte and Martins, 2013) as a measure of the assessment levels. This rubric was then applied in three university case studies, which reflected a range of university innovation ecosystem implementation levels.

4.4.1 Assessment rubric for AUIEA

The AUIEA assessment rubric (Appendix D) was structured using the assessment items in the final survey (which can be seen in Appendix B). The 91 items reflect a total of 21 sub-dimensions, which are in turn associated with four leading dimensions of Leaders, Educators, Innovators, and Connectors. These dimensions, as has been discussed previously, are based on the actors involved in the university innovation ecosystem. In essence, the rubric is based on the final model as has been discussed in the previous section. There were two key issues that arose in the development of the assessment rubric from this source material. These issues were how to design the rubric for assessment and how to score the rubric.

The design of the rubric required some experimentation to arrive at an effective approach, because of the wide possibility of approaches for development and the limited information on quality assessment rubrics. A rubric is a tool that evaluates performance on certain specific criteria in a standardized fashion (Reddy and Andrade, 2010). Rubrics are designed using three components: 1) The evaluation criteria for the task or other thing measured, 2) The quality definitions that apply to them, 3) A scoring strategy that is used to assess performance (Reddy and Andrade, 2010). Furthermore, rubrics may be designed either as analytic rubrics or holistic rubrics (Dawson, 2017). The difference between these two approaches is that an analytical rubric provides an individual score for each component, while a holistic rubric provides an overall score but does not decompose it into individual elements (Dawson, 2017). Since most research into the use of rubrics is in student assessment (Reddy and Andrade, 2010), rather than in quality assessment or related approaches, there was limited guidance on the approach used. Some of these choices were straightforward. For example, it was clear that the items from the questionnaire should be used as the evaluation criteria, since these were the measures on which innovation and entrepreneurship ecosystems were being assessed. Furthermore, since the objective of the rubric is to target opportunities for improvement, it was also obvious that the analytical scoring approach should be used, rather than a holistic scoring approach which would only give an overall score. However, some issues were more challenging.

One of the challenging questions was how the performance should be defined. The two approaches that were contemplated included developing individual performance levels for each item and using an overall performance level scale based on the CMMI for all items (Constantinescu and Iacob, 2007; Paulk, 2009; Duarte and Martins, 2013). It was reasoned that the first approach would be more precise, since individual statements could be developed to assess performance at each level. This approach was attempted, but it was recognized that this did not lead to equivalent rankings between items. Furthermore, there was also the problem that internal organizational structures and their differences may not be consistent between universities, which would be a threat to the reliability of the rubric (Jonsson and Svingby, 2007). The second approach was to use a standard performance measure based on the CMMI, with explanations provided that would allow respondents to assess the level of performance without unnecessarily stringent specifications. This approach also has problems, in that this type of measure can lead to assessor bias (Debusk, 2008). As Debusk (2008) points out, this is not the only type of organizational instrument that can be subject to such bias. The solution arrived at was the use of a standard measure for each level, along with the use of multiple raters for each of the institutions. This strategy was chosen because the use of multiple raters is an acknowledged way to offset bias in assessment practices (Jeong et al., 2018).

The second challenge in the development of the rubric was establishing a scoring mechanism. There were several possible approaches that could be used, and the choice of approach was based on the intention for the rubric to serve as a developmental assessment tool rather than an overall performance measure. In response to this requirement, the measurement strategy began with individual items, whose scores could range from 0 to 5 (based on the CMMI model). Respondent scores for individual items were averaged, with respondents who chose "NA" for an item excluded from the average. The individual items within the sub-dimension were then added together, leading to an unweighted score for each of the dimensions. After this, the unweighted scores of the sub-dimensions were added together, resulting in a total score for each dimension. To assess the maturity level, the responses were assigned by quintile groups, as explained in the next section. Finally, this maturity level is assessed using the CMMI framework to determine the overall maturity level within the dimension. This scoring process is illustrated in Figure 21, using a theoretical Educators sub-dimension to show the scoring process.

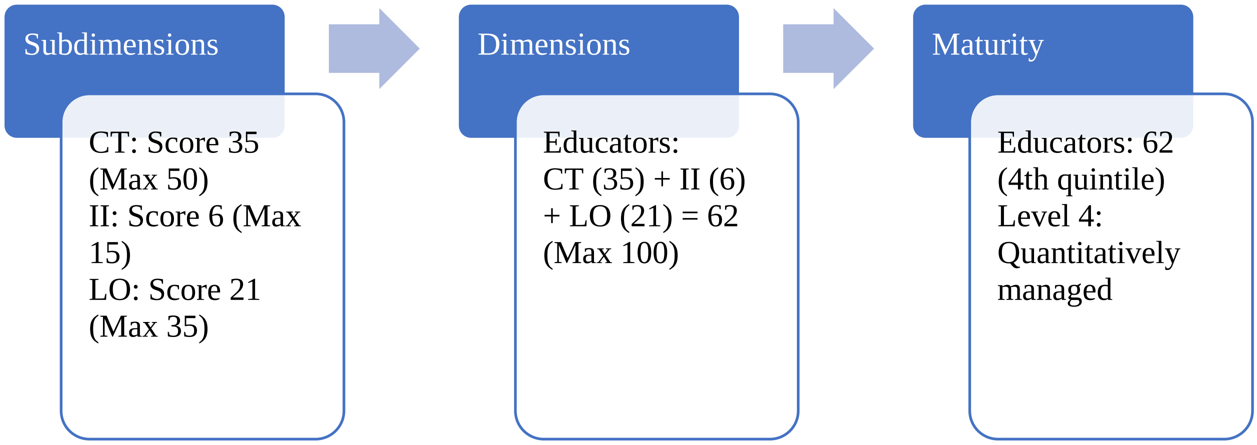


Figure 21 An illustration of the scoring approach

Note: CT = Curriculum and Teaching; II = Industry Involvement; LO = Learning Outcomes. Max scores represent the maximum total possible in the individual dimension or sub-dimension; e.g., Curriculum and Teaching (CT) has 10 items x 5 points for a max score of 50. Actual Scores represent the individual item scores x 5. For example, the score of 35 in CT indicates that 10 items had an average mean score of 3.5 (out of 5)**.**

The use of an analytical rubric meant that information on the score for individual items was provided to respondents, which would allow them to target specific areas for development and improvement depending on the university's current position. The rubric scoring was designed to provide some specific information, which included:

Aggregate scores (averaged across all participants, with "NA" responses excluded) for individual items

Aggregate scores for sub-dimensions

Aggregate scores for dimensions

Numeric and maturity score for each dimension (based on aggregate scoring)

The use of average scores were designed to minimize the problem of respondent bias through the use of multiple raters (Jeong et al., 2018). The aggregate scores for individual items, dimensions, and sub-dimensions are designed to allow users to pinpoint problematic areas; for example, being able to identify that the institution needs to add innovation to its vision or policies. The numeric and maturity scores are at the dimensional level, to provide a quick overview of the current state of development of the university's innovation ecosystem. Thus, this scoring system offers multiple levels of detail, enabling data users to do anything from a quick check-up to detailed analysis of the innovation ecosystem. This was preferred to using only one level of analysis, which would either be too general or too specific.

In addition to the numeric data, reports included analytical data, including identification of key areas for performance improvement (for example, items or sub-dimensions which were lower than others), an explanation of the scoring levels and maturity levels. The implementation of these rubrics is explained in the next section, which reviews the case studies.

4.4.2 Validating AUIEA using Case Study in Thailand

The AUIEA model was validated using three case studies of universities in Thailand (CU, CMU, and KU). To complete the case studies, two officials from each of the university, who had previously participated in the study, were sought out to complete the assessment for each of the universities. These responses were then averaged in order to form the basis for scoring.

4.4.2.1 The scoring system

The scoring system was developed as follows as summarized in Table 20. The maximum number of points available in each category was equivalent to the number of items included in the final sub-scale, multiplied by the maximum possible score (5). For example, the Leaders dimension, with a total of 29 items across all sub-dimensions, was worth a maximum of 145 points. The scoring system used a weighted score based on the factor loadings from the third stage (see Table 19 for reference). To calculate the score weights, the total factor loadings for each scale were added, then the percentages of each factor loading were calculated for the subdimensions. For example, the Resource Management (RM) sub-dimension of the Leaders dimension, whose factor loadings accounted for 20% of the total, was worth a maximum of 29 points. To calculate the total score for a dimension, the mean scores for each item in a sub-dimension were added together, then multiplied by the sub-dimension's weight. The sub-dimensions were then added together for the actual dimension score.

Table 20 Calculation of raw scores for AUIEA assessment test

Dimension	Sub Dimension	Weight	Total score
Leaders	Governance and culture (GC)	0.22	31
	Policies and Strategies (PS)	0.19	27
	Resource management (LRM)	0.22	32
	Stakeholder engagement (SE)	0.20	30
	Vision (V)	0.17	25
	Total		***145***
Educators	Curriculum and teaching (CT)	0.40	40
	Industry involvement (II)	0.32	32
	Learning outcomes (LO)	0.28	28

Dimension	Sub Dimension	Weight	Total score
	Total		***100***
Innovators	Production (IP)	0.14	19
	Commercialization (IC)	0.12	16
	Funding and Financial Management (FFM)	.14	18
	Incentive and Reward Systems (IRS)	0.11	14
	Training and Mentoring (TM)	0.11	16
	Role Models (RM)	0.12	17
	Business and Innovation Development (BID)	0.13	17
	Faculty Involvement (FI)	0.13	18
	Total		***135***
Connectors	External collaboration (EC)	0.22	17
	Internal collaboration (IC)	0.19	14
	Industry connections (ICO)	0.22	16
	Entrepreneurial Education (EE)	0.20	15
	Entrepreneurial Hub (EH)	0.17	13

Dimension	Sub Dimension	Weight	Total score
	Total		***75***

Note: Weight is based on factor loading (Table 19). To calculate weights, factor loadings of all dimensions in the scale were added. The proportional factor loading to the total was then calculated for each sub-dimension. This proportional factor is used to determine the total number of possible points per sub-dimension in contribution to the scale.

These scores can be interpreted using the rubric offered in Table 21. The rubric is based on the CMMI framework (Paulk, 2009; O'Regan, 2010; Duarte and Martins, 2013). Therefore, scores of 0 were interpreted as "Incomplete" – in other words, the university was not implementing any activities in this domain at all. Scores within the first quintile (1% to 20%) were classified as "Performed" – there is some of this activity happening, but it is not yet being managed and is typically bottom-up and ad hoc. The second quintile (21% to 40%) were defined as "Managed" – the activities are being reactively managed, often at the department or group level. The third quintile (41% to 60%) are "Defined" – they have been established in university-wide policy and procedures and are clearly defined and understood. The fourth quintile (61% to 80%) are "Quantitatively Managed" activities – they have clearly defined and objective targets that are used to assess and manage performance. The final quintile (81% to 100%) are "Optimizing" activities – they are fully defined, stable, measured and managed, and are now being refined.

Table 21 Calculation of operational levels for individual dimensions

Score				Level	Definition
Leaders	Educators	Innovators	Connectors		
0	0	0	0	0	Incomplete
1-28	1-19	1-26	1-14	1	Performed
29-57	20-39	27-54	15-29	2	Managed
58-86	40-59	55-81	30-44	3	Defined
87-116	60-79	82-107	45-59	4	Quantitatively Managed
117-145	80-100	108-135	60-75	5	Optimizing

The final maturity model is based on the average level scores from the operational maturity rubric, as shown in Table 22. This maturity model is based on prior capability maturity models, which have established a sequence of maturity levels for both software and organizational development (Paulk, 2009; Crowston and Qin, 2010; Duarte and Martins, 2013). Particularly, the maturity model follows the research of Duarte and Martins (2013), who took up the problem of maturity modeling for universities as institutions. To estimate the maturity level of the university innovation ecosystem as a whole, the achieved levels for each of the four dimensions of Leaders and Governors (L), Educators (E), Innovators (I) and Connectors (C). A university's overall score of 1 to 1.49 indicates that innovation and entrepreneurship in the university is still ad hoc. A score of between 1.5 and 2.49 means the university has begun to pilot its innovation ecosystem implementation, while between 2.5 and 3.49 the innovation ecosystem is being managed in terms of functional processes and activities, but has not yet become fully embedded within the institution (Paulk, 2009). Between 3.5 and 4.49, the university's innovation ecosystem is fully institutionalized, meaning it is fully incorporated into the organization's vision, strategies, and culture as well as operations (Crowston and Qin, 2010). Finally, the highest level of optimized and integrated (scores above 4.5) indicate that university's innovation ecosystem has been fully integrated into the organization's processes and has little room for further improvement. This maturity level is an overall comparable assessment of the university's innovation ecosystem, which incorporates all the information from prior assessments. However, the decomposed level assessments also provide useful information, which will be shown in the three case studies below. The case studies included CU, CMU, and KU.

Table 22 Maturity levels of AUIEA model

Level	Score	Mature Processes
Level 1	**score** 1-1.49	Ad hoc
Level 2	**score** 1.5 -2.49	Piloted
Level 3	**score** 2.5 –3.49	Managed

Level	Score	Mature Processes
Level 4	**score** 3.5 –4.49	Institutionalized
Level 5	**Score more than** 4.50	Optimized and Integrated

4.4.2.2 Case Study 1: Chulalongkorn University (CU)

The first case study was conducted at CU. CU is one of Thailand's premier research universities, as well as one of its largest and oldest. CU's university objectives include scientific and social innovation, and the university has actively pursued development of its innovation ecosystem in recent years. CU was founded in 1900 as the Royal Page School, with an initial mandate to train civil servants for Thailand's growing public service (CU, 2022b). In 1917, it was re-established as CU (CU, 2022b). Today, CU has a total of 37,626 students and 8,138 faculty members across 23 different colleges and research institutes (CU, 2022b).

CU's Vision is to be a "world class national university that generates knowledge and innovation necessary for the creative and sustainable transformation of Thai society (CU, 2022b)." The university's core strategies include human capital, knowledge innovation, local transformation, and global benchmarking (CU, 2022b). For the purposes of this research, CU's knowledge innovation strategies are very interesting. These strategies include:

"2.1 Producing research work that is able to guide and mobilize the development of Thai society; 2.2 Producing research work that is able to guide and mobilize the development of global society; 2.3 Creating an innovative ecological system that caters to academic and national development; [and] 2.4 Employing a management system that is renowned for its transparency, flexibility, proficiency, high quality, and efficiency (CU, 2022b)."

These strategies indicate that the knowledge and innovation production are at the heart of CU's strategic and leadership priorities.

The innovation ecosystem at CU appears to be well-developed. The university has an innovation hub that coordinates research and development, innovation education, and other innovation activities on campus (CU, 2022c). The university also hosts a number of research clusters in areas of interest, including Advanced Materials, Aging Society, ASEAN Studies, Automation Robotics, Climate Change and Disaster Management, Energy, Food, Health, and Social Development and Human Security (CU, 2022c). These are interdisciplinary research clusters with faculty and research staff participation from across CU, which focus on specific research areas and/or social outcomes. Other internal activities for innovation include a Community of Practice (CoP) networking function, which allows for the sharing of knowledge and the CU intellectual Repository, which hosts full-text published works from all fields. CU has also extended its innovation ecosystem into a business development area, with the Siam Innovation District serving as a university-linked spin-off and entrepreneurial incubator district near the campus. Overall, therefore, it can be stated that CU is actively developing its innovation ecosystem, and that its innovation ecosystem shows many of the aspects of maturity that were identified within the model development process.

CU's Innovation Hub has identified key characteristics of its innovation ecosystem (CU, 2022a). These aspects, as shown in Figure 22, include research and development (inputs), incubation and acceleration of new enterprises (the innovation process), and social contribution and commercialization (the outputs). Each of these dimensions has its own specific objectives and strategies. The Research and Development aspect CU's innovation ecosystem includes objectives such as stakeholder engagement, finding and connecting funding to projects, strengthening skills, connecting industrial partners, facilitating services, and providing intellectual property (IP) knowledge and legal support. In the Incubation and Acceleration domain, key concerns including mentoring, scaling up innovations, connecting to venture capital, lab facilities and teams, and IP services. At the Social Contribution and Commercialization Stage, CU's innovation ecosystem is concerned with outreach, technology transfer, and connection to marketplaces (CU, 2022a). Therefore, the innovation ecosystem developed at CU's innovation hub is fairly complete, but it is mainly viewed from the position of the innovation hub and its activities. Thus, CU could consider how the innovation ecosystem is implemented across the university. Thus, even though, as will be shown next, CU has a mature innovation ecosystem, there is still a use for application of the AIUEA model.

Figure 22 The CU Innovation Ecosystem (CU, 2022a)

Table 23 summarizes the outcomes for CU at the primary dimension level, including the maximum possible points, the points achieved, and the level assigned. The overall assessment of CU (table 27) shows that at the primary dimension level, CU is operating at the Optimized level, indicating that although there may be some improvements to be made in the individual processes, essentially all the elements of the university innovation ecosystem are in place. This included the Leaders and Governors domains (128/145), Educators (91/100), Innovators (115/135), and Connectors (67/75). This was what was expected given the development of the innovation ecosystem as discussed above.

There are some opportunities for improvement. For example, within the Innovators dimension, CU was relatively weak in the FI dimension, indicating that there are more opportunities to improve faculty involvement in the innovation activities of the university. These results confirm the overall assessment that CU has a well-established innovation ecosystem, which does need to be refined slightly but which overall is mature and meeting all the requirements of the AIUEA model.

Post-assessment interviews with the respondents for CU did identify some opportunities for improvement. One of these opportunities was to present items one at a time, rather than in a list. As one of the respondents noted, this would have made it easier to focus on the individual items and questions. The second recommendation is that more detailed assessments should be provided of the outcomes, whether they are performing well or need further adjustment. This is a good point; as the recommendations were designed to be developmental, the model was not designed to provide feedback on dimensions that were performing well. This would leave a university like CU with little overall feedback, which is a problem given how intensive the assessment process is. Overall, the respondents felt the scoring and assessment was fair and it would be a useful tool for identifying opportunities for improvement.

Table 23 AUIEA Assessment outcomes: CU

Dimension	Maximum	Score	Level
Leaders and Governors (L)	145	128	5
Educators (E)	100	91	5
Innovators (I)	135	115	5
Connectors (C)	75	67	5
		Sum Level	20
		Average Level	5
		Maturity Level	Optimized and Integrated

Note: Scoring is calculated based on the number of items within a dimension times the mean score for the item. For the Maximum scores, this represents the Item Number x 5. For the Score, this represents the actual sum of mean scores for all items within the scale. For example, in the Leaders and Governors dimension, there were a total of 29 items across the five sub-dimensions, leading to a maximum possible score of 145. The actual score of 129 represents the weighted actual scores for CU. This meant that CU scored 88.9% of the possible maximum, placing it in the fifth quintile or level 5.

4.4.2.3 Case Study 2: Chiang Mai University (CMU)

CMU is one of Thailand's largest public research universities, with a strong focus on STEM and agricultural education. CMU, which was founded in 1964, is the first and largest university in Northern Thailand (CMU, 2022). Today, it has an estimated 35,900 students, along with 2,171 faculty members in approximately 27 faculties (CMU, 2022). Most of these faculties are in science, technology, engineering and medicine (STEM) fields, indicating the university's heavy focus on the innovation.

CMU's Vision is of "A leading university committed to social responsibility and sustainable development (CMU, 2022). This Vision is supported by its mission statement, which includes four missions: "1) Effectively train students; 2) Conduct diverse research to uphold our standards of teaching, learning and technology transfer and to adapt innovative knowledge. 3) Provide academic services to the national community in line with the Sufficiency Economy Philosophy, particularly serving northern Thailand, and 4) Preserve and nurture our Lanna-Thai heritage, and sustainably developed the resources of the unique natural environment of Thailand (CMU, 2022)." These priorities suggest that teaching and knowledge transfer, rather than research, are CMU's main strategic priorities.

There is some evidence that CMU is in the process of developing a robust innovation ecosystem, even though its priorities remain focused on teaching. The CMU Science and Technology Park (STEP) houses and coordinates the university's spin-offs and serves as an entrepreneurial incubator, enabling resource sharing and coordination (STEP, 2022). STEP (2022) is a collaborative organization between seven of the university's departments, including the Engineering, Science, Agriculture, Agro-Industry, Architecture, Business Administration, and Art and Media and Technology faculties. STEP serves as a limited innovation hub, including innovation commercialization services, one-stop professional services and business development services, and support for services to bring together private sector, education, government and community sector partners in what it terms a quadruple helix model of innovation and business development (STEP, 2022). Therefore, it can be seen that STEP and the services it provides do potentially form the basis for an innovation ecosystem, but these services are limited in that they are only available to certain faculty and departments.

However, there are some notable aspects of the university innovation ecosystem that are not immediately obvious. For example, there is no obvious signs of a university-wide innovation hub, with STEP only serving a small number of the university's departments. Furthermore, unlike CU, CMU does not seem to have implemented university-wide policies for knowledge sharing or communities of practice. CMU also does not centralize innovation in its vision and strategies for the university, and in fact its policies and strategies only superficially mention innovation. Furthermore, there are no dedicated educational programs for education and entrepreneurship. Although these topics are addressed within the Faculty of Business's graduate degree programs in the context of module content, there is no formal program or focus on this area. Furthermore, even modules focused on innovation and entrepreneurship are limited. Therefore, the external evidence suggests that CMU's innovation ecosystem is currently under development, and there may be many opportunities for improvement of the CMU innovation ecosystem. This was supported by the assessment of the insider respondents to the validation study.

CMU is actively pursuing education in innovation and entrepreneurship, including the establishment of undergraduate and postgraduate degrees in innovation and entrepreneurship, including specialist areas of digital innovation and medical innovation. However, the university's participants in this stage of the research acknowledged that its innovation ecosystem was still under development. Particularly, one of the respondents noted that the university-wide integration of innovation activities and policies was not complete, and many innovation activities were still taking place at the individual department, school, or research group level. This is consistent with the evidence the assessment of CMU's innovation ecosystem as discussed above.

Table 24 shows the primary dimension level maturity and overall maturity results for CMU, including the maximum points, achieved points, and assigned level for each of the four primary dimensions. The dimension-level and overall results of CMU (Table 26) bear out the comments from the participants, showing that the maturity levels for the dimensions are typically 3 (Managed) or 4 (Institutionalized). Particularly Leaders and Governors (61/145) and Innovators (80/135) are at level 3 (Managed), while Educators (69/100) and Connectors (55/75) are at level 4 (Institutionalized). This indicates that there are many processes that are being managed proactively, but these are not yet fully implemented in terms of quantitative measures or assessments. Others are at the Institutionalized level, meaning that there are objective measures and controls in place across the institutions, but they still have room for optimization. The weakness of the Leaders and Governors dimension is particularly noticeable, which supports the interviewee's description of their innovation ecosystem as not yet fully guided from the top level. Thus, there are still opportunities for improvement in this area.

The post-assessment interviews with CMU's participants did provide some opportunities for improvement. Overall, they felt the assessment was easy to use. However, one participant remarked that providing the assessment items prior to the assessment completion would be useful, as this would give them time to double-check information and ensure the facts were correct. The other participant also brought this up, noting that being able to save and return to the assessment would also allow them to provide more complete information. These suggestions were implemented in the final product, as it does make sense to allow respondents the ability to carefully assess their performance. One of the respondents did mention the recommendations, noting that they were useful in understanding where the university should focus and exactly how to go about implementing a university innovation ecosystem. Overall, the experience of this university was positive, and the information provided by the assessment could be used to improve the university's integration of its innovation ecosystem.

Table 24 AUIEA Assessment outcomes: CMU

Dimension	Maximum	Score	Level
Leaders and Governors (L)	145	61	3
Educators (E)	100	69	4
Innovators (I)	135	80	3
Connectors (C)	75	55	4
		Sum Level	14
		Average Level	3.5
		Maturity Level	Institutionalized

Note: Scoring is calculated based on the number of items within a dimension times the mean score for the item. For the Maximum scores, this represents the Item Number x 5. For the Score, this represents the actual sum of mean scores for all items within the scale. For example, in the Leaders and Governors dimension, there were a total of 29 items across the five sub-dimensions, leading to a maximum possible score of 145. The actual score of 61 represents the summed actual scores for CMU. This meant that CU scored 42.1% of the possible maximum, placing it in the third quintile or level 3.

4.4.2.4 Case Study 3: Kasetsart University (KU)

The third case study was conducted at KU. Like the other two universities, KU is a large and well-established public research university, with established research expertise in agriculture and social sciences. KU was originally established in 1904, during a period in which the system of agricultural colleges was being established across Thailand (KU, 2022a). It was gradually expanded to include agricultural education and teacher training before becoming a fully-fledged agricultural university in 1943. This makes it one of Thailand’s oldest universities (KU, 2022a). Today, it has seven campuses in and around Bangkok, with an estimated 70,000 students and 9,870 staff members (KU, 2022a). KU also has a total of 29 faculties as well as various research centres spread across its campuses (KU, 2022a).

KU’s (2022) vision is to be “A world-class university committed to teaching, research, and innovation leading to the sustainable development of society based on the knowledge of the land.” In order to enact this vision, it identifies five strategies, which include: “Strategy 1: To promote and expand knowledge of the land that encourages national sustainable development in all sectors of society. Strategy 2: To continuously develop and improve on academic programs that are recognized internationally for education and research excellence. Strategy 3: To ensure high quality, operational efficiencies that will achieve the university’s mission and goals. Strategy 4: To apply principles of good governance that ensure sustainable management of the universities resources, people, and assets. Strategy 5: To continuously improve the university's administrative skills and competences, and to ensure effective management by embracing technology changes (KU, 2022a).” These objectives are firmly centralized in teaching and research in KU’s central field of agricultural research, and do not directly mention innovation or entrepreneurship activities as such. Therefore, it does not appear that innovation ecosystem development is one of KU's strategic priorities at present.

This perception is borne out when considering the evidence for KU's innovation ecosystem. KU actively engages in research in selected fields, including publication of scientific research and maintenance of a total of 25 field research stations in faculties including Agriculture, Fisheries, and Forestry (KU, 2022c). KU does collect and publish information about the scientific output of its faculty and research divisions (KU, 2022b). This information indicates that a total of 22,234 articles and 24,385 conference publications have been achieved by the university's faculty, along with 168 copyrights (typically issued for creative works such as books) and 13 trademarks. A total of 140 patents and 345 petty patents have been issued. (The difference between a patent and a petty patent is that the petty patent, sometimes termed a design patent, lacks the necessary inventive step of the patent (Aplin and Davis, 2021).) Therefore, there is evidence that the faculty and research staff at KU do have some level of innovative output. At the same time, there are many features of the innovation ecosystem that appear to be absent from KU, particularly the required infrastructure and supports. These include an innovation and entrepreneurship hub, resources such as innovation offices that coordinate commercialization of innovations, or education and curriculum support for innovation and entrepreneurship. Lack of leadership and governance for innovation and entrepreneurship has already been touched on above, which probably explains the gap in infrastructure and coordination. Overall, therefore, KU does have active research happening, but does not appear yet to have basic infrastructure or leadership required for the development of a connected innovation ecosystem.

KU does have several different innovation directives, including separate research and innovation centers for agricultural sciences and other scientific domains. However, it is still developing a university-wide innovation and entrepreneurship policy, and does not yet have a comprehensive innovation and entrepreneurship education and development program in place. One of the participants from KU described its innovation ecosystem as “a work in progress”, and this is consistent with their current state of development.

The summary of KU’s assessment outcomes (Table 25) shows that overall, the assessment agrees with the stated position of the respondents. Currently, KU is at the managed maturity level, meaning that overall, innovation and entrepreneurship is being managed, perhaps in a reactionary, fragmentary and inconsistent way. Furthermore, it implies that the management of innovation and entrepreneurship is inconsistent, taking place at the department and work team level. One of the particular areas of weakness was in the Entrepreneurs (E) dimension, where the individual scale results showed weaknesses in centralization of incentive and reward systems, funding and financial management, training and mentorship, faculty involvement, and business innovation development, as well as entrepreneurship hub.

When asked about these results, the KU representatives agreed that this was an area of particular weakness. As one explained,

> “These are things we are working toward, but right now this is all managed at the school or even the department level. For example, while the agricultural sciences department have innovation funding and teaching activities, other departments do not. This means that while there is certainly innovation

happening in the university, it is not yet centralized or coordinated. We have limited resources, especially knowledge, and there are barriers like departmental separation that limit our ability to implement university-wide innovation ecosystems."

This is a particularly powerful explanation of the barriers to innovation ecosystem implementation, and one that deserves to be addressed within its own research in future studies. It also provides a clear explanation for many of the gaps in KU's current implementation level.

With regard to the experience of the assessment itself, the KU participants did express some concerns, including the depth of information needed. One of the participants noted that no individual was likely to have this information, which is a good point and one that justifies the use of multiple raters. However, the KU respondents did feel it was a useful assessment, and the feedback was sufficient to identify areas for improvement. Thus, overall they were satisfied with the experience of the survey. One noted that the information from the assessment would be useful if it were formally conducted to improve the university innovation ecosystem performance, which is a strong validation of the ultimate purpose of the study.

Table 25 AUIEA Assessment outcomes: KU

Dimension	Maximum	Score	Level
Leaders and Governors (L)	145	62	3
Educators (E)	100	70	4
Innovators (I)	135	58	3
Connectors (C)	75	38	3
		Sum Level	13
		Average Level	3.25
		Maturity Level	Managed

Note: Scoring is calculated based on the number of items within a dimension times the mean score for the item. For the Maximum scores, this represents the Item Number x 5. For the Score, this represents the actual sum of mean scores for all items within the scale. For example, in the Leaders and Governors dimension, there were a total of 29 items across the five sub-dimensions, leading to a maximum possible score of 145. The actual score of 62 represents the summed actual scores for CU. This meant that CU scored 42.8% of the possible maximum, placing it in the third quintile or level 3.

4.4.2.5 Summary of case studies

These three case studies have illustrated how both the individual dimensions and the overall maturity level offer information about the university's innovation ecosystem development. The post-assessment interviews also provided useful information on the user experience and feedback provided by the assessment, which were integrated into later development activities to improve the performance of the AIUEA tool for other universities. This information can be used to compare university innovation ecosystem development. It therefore offers a supplement to the more detailed information from the full assessment, which can be used to identify the university's gaps and opportunities for improvement.

4.5 Chapter Summary

This chapter has presented the findings from the three-stage, mixed methods research process which was used to develop the AUIEA. The Delphi study resulted in a set of 91 items, ranged across four dimensions, in a preliminary assessment model. These four dimensions included a total of 21 first-order constructs, which represented different aspects of the innovation dimension. However, one proposed dimension – Agents of Change – was removed from the model entirely due to its rejection during the Delphi study. When tested in a survey of ASEAN-based university innovation experts, this was reduced to a total of 64 items, which fit within the framework proposed. The third stage of the research applied the model developed from the ASEAN expert survey to a wider sample of Asia Pacific university innovation experts. The analysis of this model broadly confirmed the validity of the model but did suggest that there may be some reliability problems, particularly with the Leaders and Governors dimension. Finally, a series of case studies was conducted where the rubric developed to measure the assessment items was conducted by real universities, which enabled a test of the final measurement model and the opportunities for improvement. The outcome of this stage showed that the model did reflect differences in the innovation ecosystem of the universities as well as providing insight into how the model could be improved for application. The final model derived from the research, presented above, is the subject of the next chapter, where commercialization and distribution of the model are presented.

CHAPTER V
COMMERCIALIZATION DEVELOPMENT OF AIUEA ASSESSMENT WEBSITE

In Chapter 4, a finalized AUIEA framework was presented, based on findings from a three-stage research process. This model included four role-based dimensions of Leaders and Governors, Educators, Innovators and Connectors. Within each of these roles were specific process dimensions, which reflected how the role assisted in promoting innovation and entrepreneurship in the university. The finalized research instrument paired with the model provides a basic tool for measuring and assessing university innovation, when paired with an established set of metrics specific to the university.

This chapter's objective is to take this model and research instrument as the basis for a commercialized product. It begins with an overview of the website development process and consideration of key issues. It then presents the commercialization plan, including the management, operating operational, and financial plans. Next, it presents the implementation plan. The chapter concludes with a risk management plan.

5.1 Website Development

The main channel for distribution of the AUIEA performance assessment model will be via an assessment website, which will be developed by the researcher in cooperation with several strategic partners. In this chapter, the website envisioned for the AUIEA assessment tool is described. This section begins with an overview of the website development process. Use case diagrams for the website are then offered. The processes for the rubric-based analysis and the generation of recommendations for improvement is explained. Key issues of data privacy and user acceptance are also discussed, as these have been identified as key challenges for dissemination of the AUIEA assessment website and tool.

5.1.1 Overview

The AUIEA Assessment Framework website will serve as a platform for collecting and analyzing innovation ecosystem assessment data and providing recommendations based on cumulative institutional results. The website is centered around a dashboard, which allows the users to take specific, role-based information and actions. This dashboard, depicted in Figure 23, allows the user to set up surveys, complete surveys, view results, and perform other tasks based on their permissions. To use the dashboard, users must log in to the server.

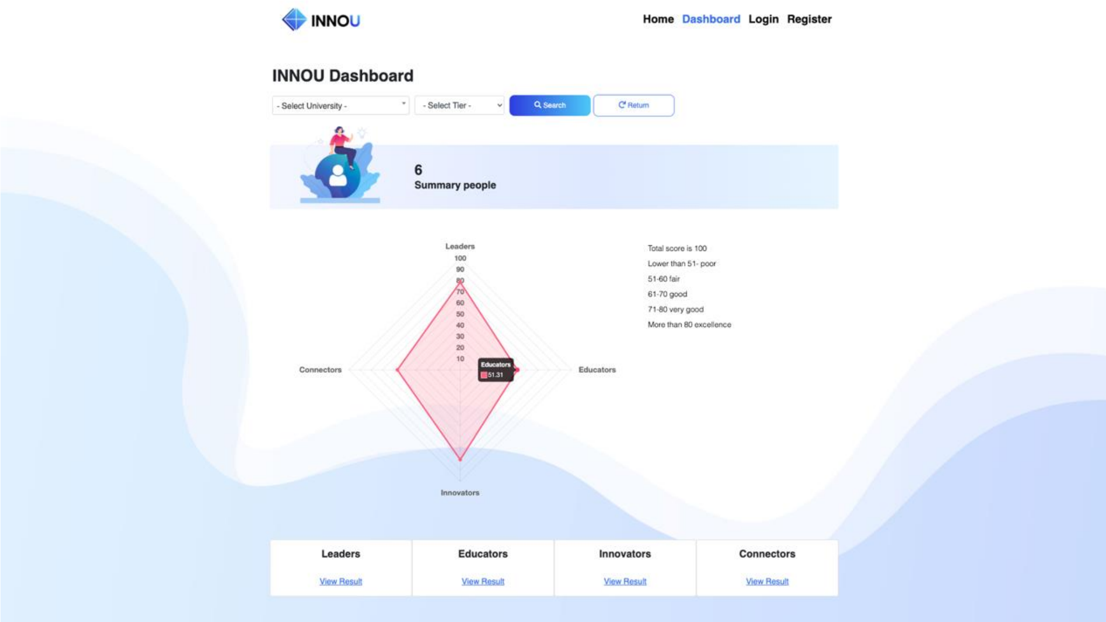


Figure 23 The website dashboard

The two customer roles include User and Administrator. Users will be limited to taking surveys they have invites to and viewing aggregate data about their university (following closure of the survey). Each university will have one or more Administrators, who can open and close surveys, invite users to surveys, generate recommendations, and view more detailed information, including individual item rankings and ratings, which will allow for targeted development and policymaking. This ensures that Users can complete surveys and view transparent data about the survey outcomes, while Administrators have specific recommendations to act on in order to improve their university's innovation ecosystems.

Users are assigned permissions by tiers of Professor, Management, Researcher, and Partner, which are used to refine the permissions and questions they are asked and to collect statistical information for the university survey. These tiers are role-based and determined by the individual's self-reported primary job role. Therefore, educators will use the Professor tier, university administrators and leaders will use Management, those engaged primarily in research activities will use Researcher, and private-sector, government and third-sector partners will use the Partner tier. Users have three key actions, including registration, profile, and questionnaire completion.

The registration process, depicted in Figure 24, collects information from the user in order to assign them to the correct university and survey. The respondent selects the university they are completing a response for, and then provides contact information including mobile number, email, and first and last name, as well as their respondent tier. This creates a registration based on their email address, as well as a pending assignment to the questionnaire. In order to avoid uninvited sign-ups, the assignment to a specific university survey requires confirmation from the survey's designated Administrator.

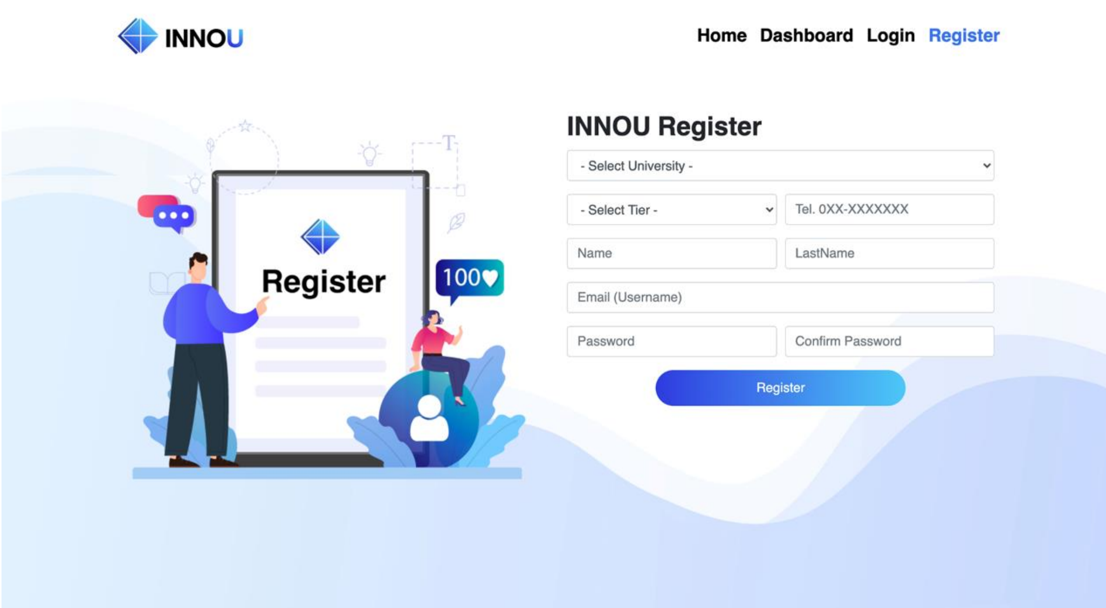


Figure 24 The website registration process

The user interface also includes a profile, which is shown in Figure 25. Here, the user can view and modify information in their profile, including professional and contact information and passwords. They can view completed questionnaires under Questionnaire History. They can also begin another questionnaire under Go To Questionnaire. This option opens a secondary menu that is used to direct the user to any questionnaires in progress.

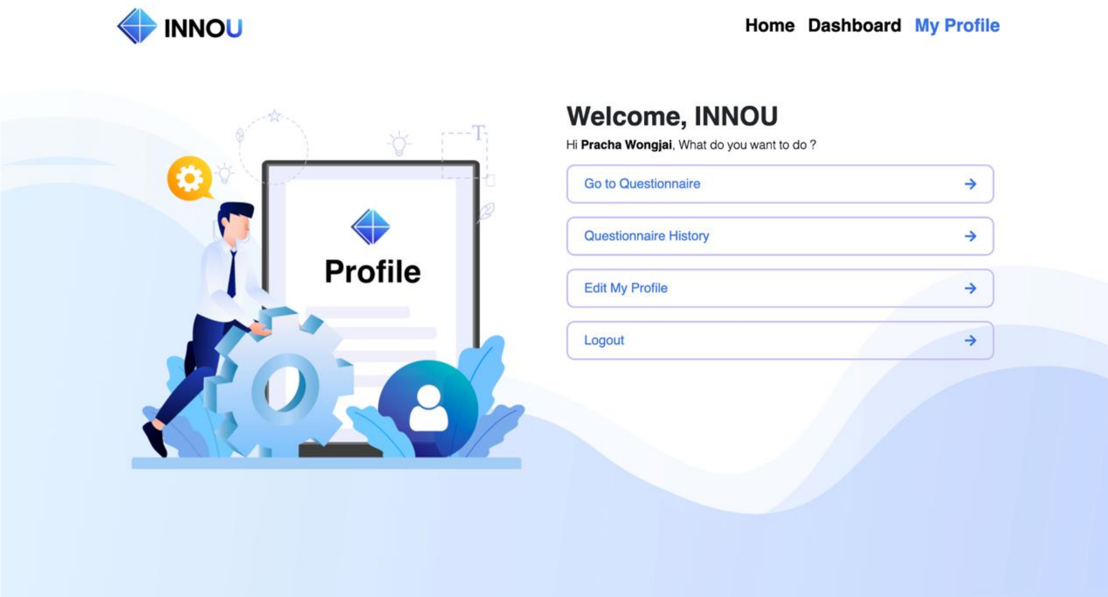


Figure 25 The user profile

The main activity for users is completing questionnaires. The questionnaire (as shown in Figure 26) is designed using radio buttons, to allow users to select only a single response to each item. The items are presented in order within the primary dimensions and sub-dimensions of the AUIEA framework, beginning with Leaders and Governors. For each statement within the framework, respondents are asked to rate its importance on a Likert scale of 1 to 5. The user can save the questionnaire at any point and return to it later (up to the pre-set closing time of the questionnaire). When the user has completed the questionnaire, they click 'submit' to complete. They are also offered the opportunity to submit feedback at the end.

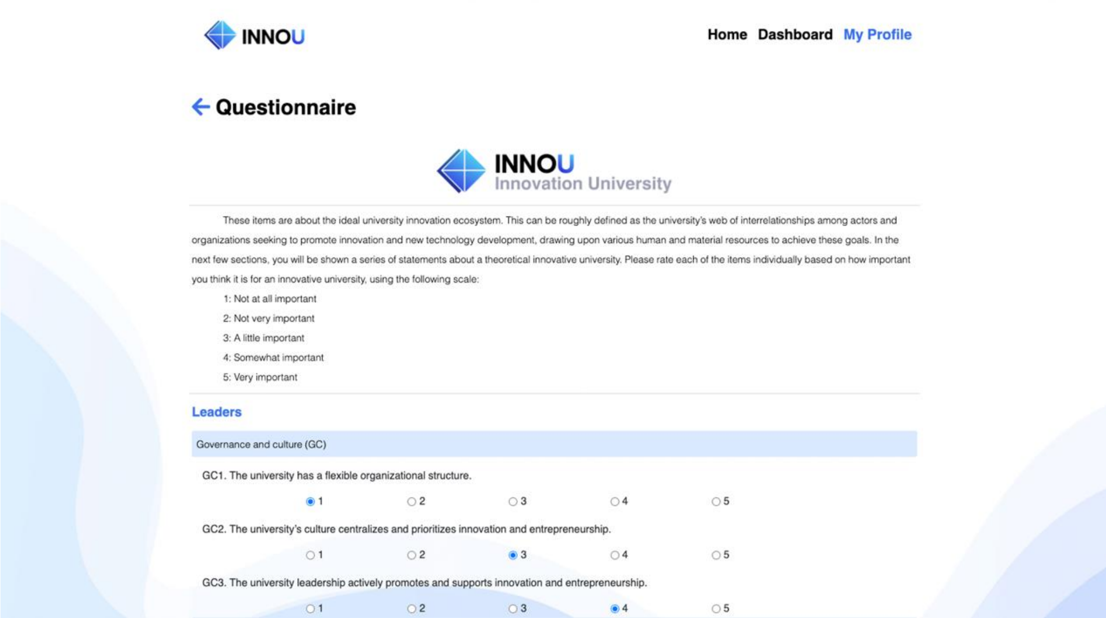


Figure 26 The user view of the questionnaire

5.1.2 Use case diagrams

Use case diagrams have been prepared for the front end and back end of the User journey. These use case diagrams illustrate how the User (who takes surveys and manages their profile) can step through the process of using the website.

Figure 27 shows the user's journey from the front end perspective. The user begins by registering an account, which is validated by the administrator to associate them with a specific university. The user can then view the dashboard, log in and log out. When the administrator opens a survey, the user (or members) who are invited to the survey can complete the questionnaire that is associated with the survey. They can also view general results, including the radar chart (discussed below) and the questionnaire history. Administrators have the same permissions, and can also view and edit member details.

There are three system roles (User, Member, and Admin), each of which has slightly different permission sets. These permission sets are cumulative, meaning that Members also have User permissions, and that Admins have User and Member permissions. Member and Admin permissions are assigned per questionnaire, while User permissions are global.

The User role is the basic level of permission, granting access to the system. The actions that are possible for this role include:

Register: Sign up to the system and request access to a questionnaire. (This request is then forwarded to the associated Admin for approval.)

View Dashboard: Viewing the user dashboard that provides access to user functions, including viewing and modifying profiles and accessing current and completed questionnaires.

Login/Logout: Allows the user to log in and out of the system.

The Member role is assigned when the Admin approves the request of a User to access a particular survey. The Member role includes the following additional permissions:

Take a Questionnaire: Allows access to all in-progress questionnaires for which the User has permission.

View RadarChart Result: Allows the user to view the results of the questionnaire in aggregate for all respondents.

View Questionnaire History: Allows the user to view previous questionnaires, including their responses and summary results.

At the front end, the Admin role is tasked with administration of the questionnaire itself. The potential front-end actions for admin accounts include:

Set Master Data: Allows the Admin to set up the data for the questionnaire, including university information and the addition of any custom items they want.

View/Edit Member Detail: Allows the Admin to view and edit the members associated with the questionnaire, including completed and pending questionnaires, either individually or as summary data; edit member details, including issuing invitations and approving member association requests.

View Dashboard: The administrator dashboard that provides access to admin functions for all questionnaires administered by the account.

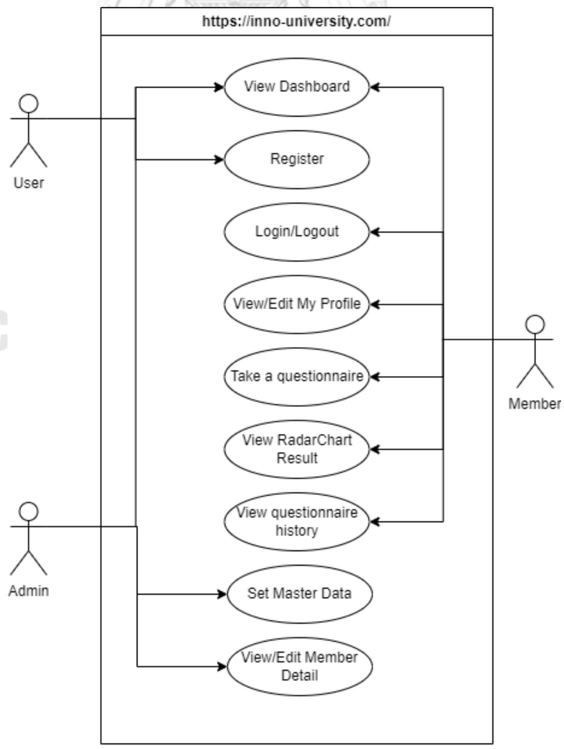


Figure 27 The user journey (front end)

The back end of the user journey (Figure 28) shows the process of User registration, login, and questionnaire completion. As this shows, the front-end, system, and administrator interact to allow the user to perform these actions. The activities of the front end (discussed above) trigger different responses in the back end/server system. For example, when a user registers, the system will check the input data and if conditions are met, pass the registration request to the administrator function for approval (Set Master Data). When a user logs in, the system checks the data and if correct, allows them to view the dashboard. If a user selects 'go to questionnaire' from the dashboard, the questionnaire is displayed and data is saved. After submission, results are calculated, then passed to the administrator, which enables them to view and analyse the data. The view questionnaire results/history are read-only activities, which display the data (based on the permissions set during the Set Master Data process). Finally, View Dashboard displays the user dashboard based on user permissions and questionnaire. These interactions are as simple as possible, in order to avoid complex workflows. While this does limit the scalability of the website, in practice it is unlikely that the website will undergo a high load that would require a more complex structure. Therefore, maintaining a simple workflow through the website was more of a priority for the initial design.

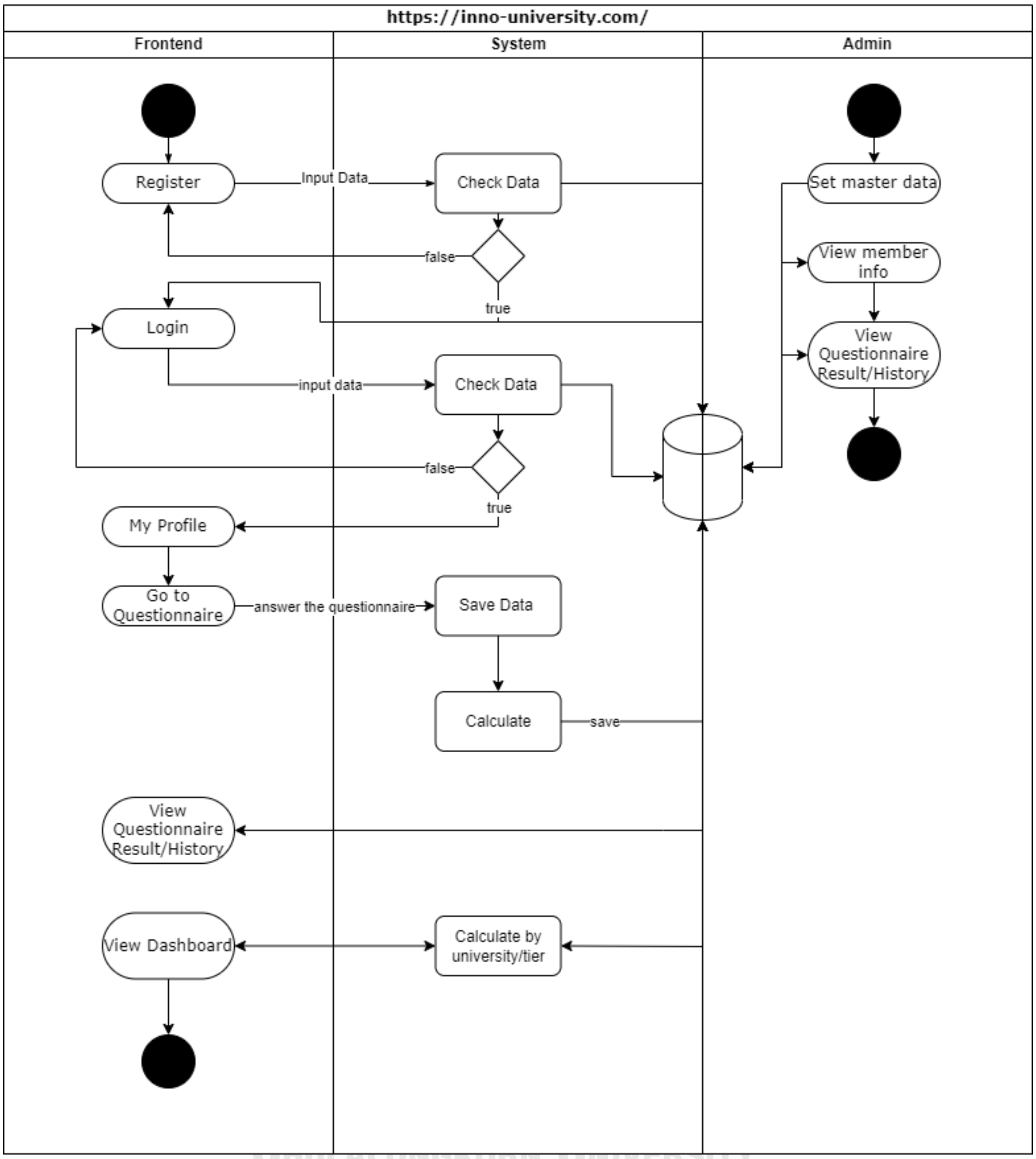


Figure 28 The user journey (back end)

5.1.3 Rubric analysis approach

The rubric-based approach to the AUIEA assessment model is used by the website to generate the overall assessment of the university. The assessment begins with the completion of the survey (64 items), which are assessed using Likert scale items. The rubric-based assessment described in Section 4.4.4 of Chapter 4 is then used to score individual sub-dimensions and dimensions. Briefly, the rubric is scored as follows. The full explanation for this process is explained in Section 4.4.1 in Chapter 4. First, responses for each individual item are averaged across all participants, which is a step which addresses the problem of respondent bias (Jeong et al., 2018). Second, the scores for the individual items in the sub-dimension are added together, which reflects the performance on each individual sub-dimension. The sub-dimensions are then added together to provide a summary measure for each primary dimension. Finally, the quintiles are calculated to determine the maturity level for the primary dimension.

These rubric-based scores are then prepared for the four dimensions (Leaders and Governors, Educators, Innovators, and Connectors). These are then averaged to establish the maturity level for the university's current operations. For the general results shown to Users, the levels of each individual dimension and the overall maturity level of the university's innovation ecosystem are shown. These levels are provided with an explanation of what the statistic means. For Administrators, who require more detailed information, the individual item scores will also be available.

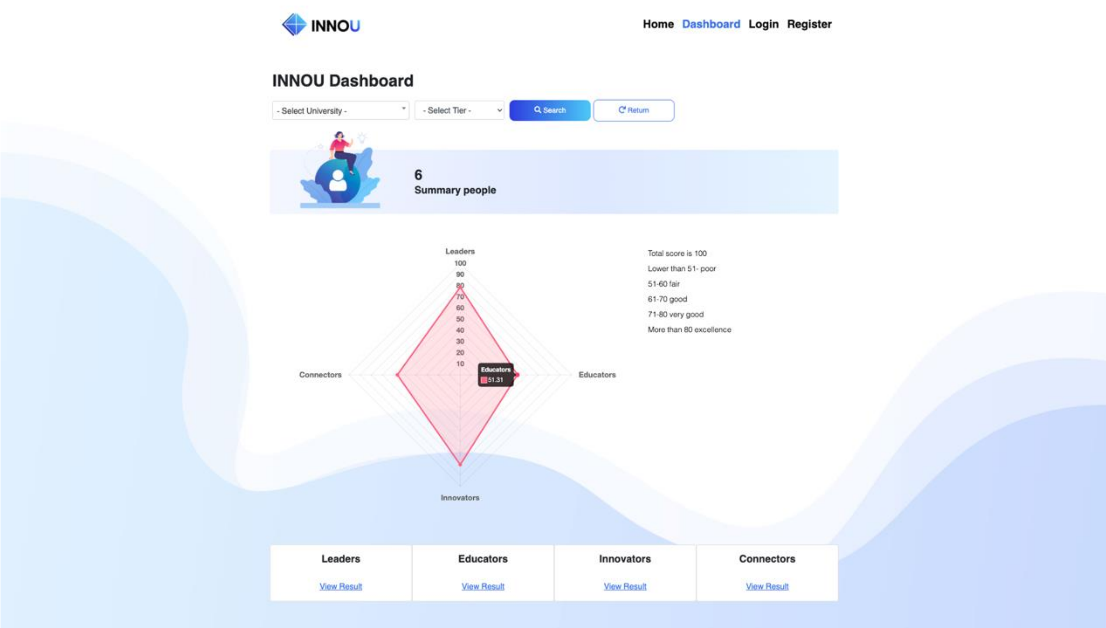


Figure 29 Summary results example

In addition to the textual description, radian charts will be provided, showing the overall performance of the innovation ecosystem dimensions, as shown in Figure 30. Users will be able to access dimensional diagrams, while Administrators will be able to view diagrams for individual items. This will assist Administrators in understanding and targeting specific areas for improvement.

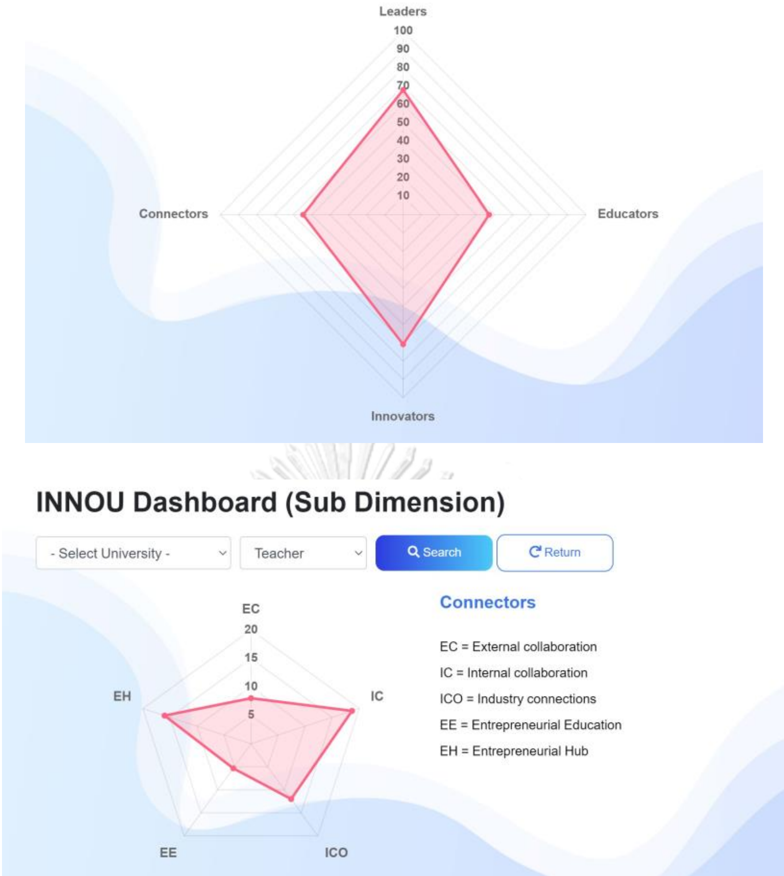


Figure 30 Example radian diagrams for university performance

5.1.4 Generation of recommendations

In addition to the survey results, the website will provide Administrators with recommendation. These recommendations will be generated from the average responses to the survey, and will be targeted to the university. Recommendations will be generated following a set process. First, the aggregated results of the survey will be analyzed by the consultants, who will identify opportunities for improvement. Some of these recommendations will come from a recommendation engine, which will be improved over time with suggestions based on the specific outcomes. This information will come from analysis of previous surveys as well as best practices that will be entered into the recommendation engine. Second, consultants will generate recommendations based on custom analysis of the survey results in consultation with the university to achieve their specific objectives.

These recommendations will be multifaceted, as there may be several different problems. For example, if a university has a low score on the item "University policy is oriented to innovation and entrepreneurship" (one of the core items in the Leaders dimension), there could be at least two problems. Like KU in the validation study, it is possible the university's vision is oriented to teaching or basic research, rather than innovation and entrepreneurship. It is also possible that the university's vision is poorly communicated, so people do not know it is an innovation orientation. Recommendations should address both possibilities. This will provide more room for universities to improve their innovation ecosystem by considering exactly what their goals are and how they can be achieved. The recommendations will be developed in partnership with the strategic partners discussed in the business model canvas, including AUN and partner universities. The exact process for recommendation development is expected to change over time, but it is expected to include comparative data from partner universities and other partners, as well as best practices from other sources.

5.1.5 Data privacy

Data privacy requirements are essential to all websites, especially those that collect personal information (Thomson Reuters, 2021). Internet privacy laws vary depending on jurisdiction, but common obligations include: protection of private and sensitive user information; disclosure of how personal information is collected, used, and retained; and obligations to limit the use of some types of information. Because Southeast Asia is a diverse region that does not have a unified data privacy law, the AUIEA assessment website will need to meet a potentially complex set of requirements. In order to address this requirement, the AUIEA website will be developed in partnership with an Internet security and privacy expert who can advise on appropriate tools for data protection, privacy, and other requirements.

The AUIEA website will use high-quality data privacy and protection tools to ensure confidentiality of information as well, including at a minimum HTTPS, strong passwords, routine patching, and if considered necessary two-factor authentication and other tools (Stallings, 2019). It will also be kept up-to-date and routinely patched to ensure privacy and security (Stallings, 2019). Because payment processing is an additional Internet security risk that requires enhanced security engineering (Stallings, 2019), payments will not be processed through the website.

5.1.6 UX/UI analysis

One of the key issues of the website is the user experience and user interaction analysis (also called UX/UI analysis). UX and UI are dependent on the user's involvement with the system and their cognitive processing of the system's tools and processes (Ji et al., 2017). Therefore, the UX and UI of a given web-based system are relevant to the usability, enjoyment and ultimately the usefulness of the system (Ji et al., 2017). The AIUEA web-based tool is not yet in use and has not been formally tested for UX and UI, but an informal UX/UI analysis conducted during the rubric validation did yield some insights into UX and UI needs for the assessment front end. These requirements included:

The system must allow users to save progress and exit, due to the extended amount of time they may require for documentation.

The assessment tools must include a N/A option, to allow users who are uncertain about aspects of the innovation process.

The assessment tool should provide pop-up definitions of key terms and reminders of the rubric's measurement schema, to ensure that users can access required information to allow them to make assessments.

The assessment tool needs to be changed to reflect university performance, rather than importance of the items for a general university.

The assessment tool should provide a reminder of the university being surveyed, as it is possible some respondents such as Partners could complete questionnaires for multiple universities.

The admin interface should provide alerts when administrators log on, to make user requests to be added to a survey visible.

Users may prefer to be able to change the interface for accessibility reasons, as one user noted that the current color scheme could cause problems for people with vision issues.

These recommendations will be incorporated into the release version of the web page. There are also other UX/UI requirements that need to be implemented prior to release. Of the known issues, the most important are localization and accessibility requirements. Localization is the process of ensuring that the language and other aspects of the web system's interface are suitable for users from different countries (Heimgärtner, 2019). For the AIUEA assessment site, the initial localization will include Thai (the home country language) and English (for broader accessibility). As the company gains customers in the wider ASEAN, official languages of other countries will also be added. Accessibility means ensuring that the user interface is suitable for all users, including those with physical or cognitive impairments that would preclude them from using the system without accessibility modifications (Barrell, 2020). Full accessibility of the system will also be a critical consideration for UX/UI testing. Later testing when the system is actually in use will include A/B testing and other live user testing in order to improve the system gradually over time.

5.2 Commercialization Plan

The commercialization plan presented in this section addresses the key issues of commercializing the AIUEA model. These key commercialization issues include 1) Management plan, 2) Marketing plan, 3) Operations plan 4) Financial plan. Within each section, description and analysis of what is needed to effectively commercialize the model as a consultation based service is explained. The commercialization plan was developed using secondary research, using a standard business plan development model as the basis for the research methodology (Ekanem, 2017). Main sources included news and industry reports, which provide insight into market conditions, costs, and other issues of relevance (Ekanem, 2017).

5.2.1 Management plan

5.2.1.1 Business description

Business name. The business name will be UIA (University Innovation Assessment).

Vision. UIA's Vision is to be the leading university innovation assessment consultant in the Southeast Asian region.

Mission. UIA's Mission is to enable the universities of Southeast Asia to leverage their existing innovation and entrepreneurial capabilities, enabling participation and engagement in global networks of innovation.

Values. UIA's Values include:

The power of knowledge. We believe that knowledge is essential for the world of today and tomorrow, and strive to both create knowledge and allow it to be used to its best advantage.

The power of innovation. Innovation is critical for humanity's future, and strive to promote it through enabling activities in the university – innovation's cradle.

The power of people. People are at the heart of everything. We value our own people, who are at the heart of what we do, and the people of our clients, without whom no innovation would exist.

5.2.1.2 Organizational chart

There are several possible alternative organizational structures that could be used, including the flat organizational structure, hierarchal organizational structure and the matrix organizational structure (Manly et al., 2017). The flat organizational structure, has few organizational levels and divisions, and instead divides responsibilities among employees to maximize autonomy and decision-making. The hierarchical organizational structure uses several organizational levels, both horizontally and vertically, to divide work and responsibilities among a large organization. the matrix organizational structure has two lines of command, the technical line and the people management line. This organizational structure is ideal for technical organizations, which are large enough to require people management specialties (Manly et al., 2017). The organization will have a flat, organizational structure, which is the most effective approach for a small and agile organization dedicated to rapid reactions to changing trends (Manly et al., 2017). It will have three central functions, including Marketing (Consultant, Coordinator, and Academic Trainer roles); Operations (Accounting);and Administration (Finance, HR, and IT). These activities will be undertaken by a variety of internal and external partners.

Since this organization is not expected to require a high level of management, it is also better to maintain the flat organizational structure as long as possible to avoid efficiency losses associated with more complex structures. Core activities include development, consulting and academic training, as well as financial management. Roles include the Director; Finance Director; Project Coordinator; Consultants; and Trainer. The Director guides the overall direction of the organization. The Finance Director manages the financial resources and strategy of the organization. The Project

Coordinator coordinates between consultants and schedules projects and resources. Consultants are tasked with customer relationship management and provision of consulting services. The Trainer, initially envisioned as a part-time role, provides system training if required for the academic partners.

The organizational chart also includes support activities, which will be outsourced to specialist service providers. These activities include Accounting Services, IP and Law Services, Marketing, and IT Services. The reason for choosing to use outsourced services for these activities is two-fold. First, the firm is not expected to require a part-time employee's worth of any of these services, except at crucial periods such as IT system setup. All outsourced activities require specialist expertise, and would be expensive to over-employ individuals if the firm cannot use their services efficiently. Since is not expected that any of the support activities will be required for full-time operations, which makes it more economically efficient to outsource the position (Ekanem, 2017). Second, as the firm will be a small and lightweight operation, it is best to make sure that it remains focused on the organization's core competencies, rather than providing support services. Therefore, it makes more sense to hire consultants and services for these domains, rather than hiring directly.

Whether to hire consultants or a full-time employee was a question for IT Services, as it was anticipated the firm would need substantial amounts of IT support. However, the firm will need IT services from several different specialties (app and web design, database design, technical assistance, and so on), which would need to be done by more than one person since these skills are different domains of Therefore, outsourcing rather than hiring one generalist is still the right decision for IT services, at least until the firm grows larger and may require part-time or full-time support from one or more IT specialties.

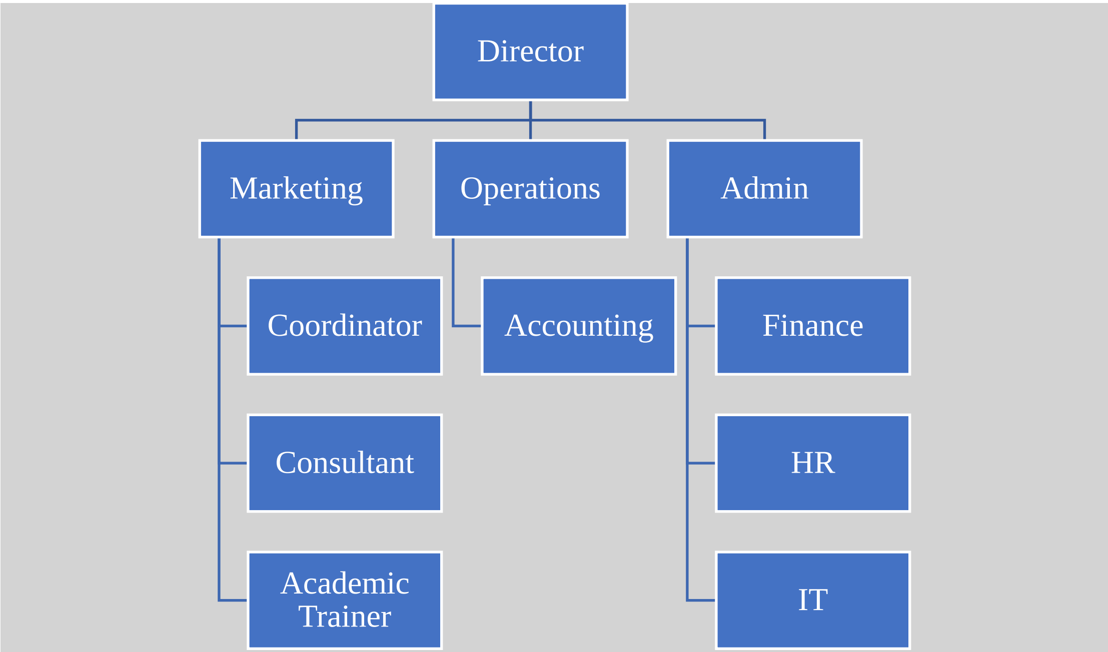


Figure 31 The organizational structure

Table 26 summarizes the brief job descriptions of each of the internal roles in the organization. While external supporting services will be selected based on cost and quality criteria (Mazzarol and Reboud, 2019), selection of internal employees will be based on their knowledge, skills, and abilities (Armstrong and Taylor, 2020). The Director has the main responsibility within the organization for a variety of activities, including vision and strategy, resource management, human resource management (HRM), investor management, and client development. Over time, it is likely that this will need to be expanded, but this can be done later in the company's operations. The Financial Director will have responsibility for the financial aspects of the firm, including setting financial strategies, overseeing financial policies, and maintaining oversight of the firm's financial resources. This role is separate from the Accounting role, which is one of the consultant services (which will fall under the oversight of the Financial Director). The Coordinator, who is tasked with general office management as well as work coordination and project management, will handle the day-to-day organization of the business. The main role of the Consultant is interfacing with university clients, including sales, facilitation, and reporting. The Academic Trainer will be tasked with preparing technical documents, training manuals and other materials and delivering technical training to academic clients. It is anticipated there will be several Consultants due to limitations on the number of clients they can serve. However, for the time being the Academic Trainer and Consultant will be single roles.

Table 26 Summary of job descriptions

Job Role	Basic Information	Roles	Qualifications
Director	Pay Range: $18,000 Reporting Relationship: Investors Hours/Week: 40	Vision and strategy development Resource management HRM activities Investor management Client development	Master in Business Administration

Job Role	Basic Information	Roles	Qualifications
Financial Director	Pay Range: $15,000 Reporting Relationship: Investors Hours/Week: 30	Financial Strategy Financial Management Financial Policies Financial Oversight	Masters in Business Administration Experience in Financial Management
Coordinator	Pay Range: $7,200 Reporting Relationship: Director Hours/Week: 20	Office management Work coordination Project management	Bachelors in Business or related field Desired: Project manager (PM) certification
Consultant	Pay Range: $14,400 Reporting Relationship: Director Hours/Week: 40	Client acquisition Client communication Client assistance Client reporting	Bachelor in Business, Innovation, or scientific fields 3+ years scientific or technical sales experience
Academic Trainer	Pay Range: $7,200	Materials development Training	Bachelor in relevant field

Job Role	Basic Information	Roles	Qualifications
	Reporting Relationship: Director Hours/Week: 20	Technical writing	3+ years scientific or technical training or writing

Note: Salary derived from estimates of related jobs in Bangkok on Glassdoor, including small company manager (50,000-60,000 baht/month), financial manager (45,000-60,000 baht/month full-time), business analyst (36,000-45,000 baht/month), and administrative employees (20,000-30,000 baht/month) (Glassdoor, 2022). These salaries are consistent with other salary estimates for managerial and administrative employees in Bangkok (Payscale, 2022; Stotz, 2020). Salaries are stated in $USD as it is an international currency and the one used for the financials in this analysis.

5.2.1.3 Product and service description

The AIUEA model will be integrated into a product and service bundle, which includes innovation ecosystem consulting services based on the web-based tool described in Section 5.1. The consulting process (shown in Figure 32) will begin by establishing the service level desired (basic and enhanced). For both service levels, the process will begin with multiple university experts completing the AIUEA assessment based on the assessment rubric. It is recommended that at least three experts be included for the purposes of bias reduction through multiple raters (Jeong et al., 2018), but the number of experts can vary depending on the university and its situation. Following assessment completion, scores are tabulated and recommendations are generated based on identified problem areas. For the enhanced service level, these recommendations are more detailed, including assessment of potential barriers to implementation and customized services to assist the university in the implementation. Universities will also have an option for longitudinal assessment, enabling them to use the tool routinely to assess progress and target policy and management activities through repeated use.

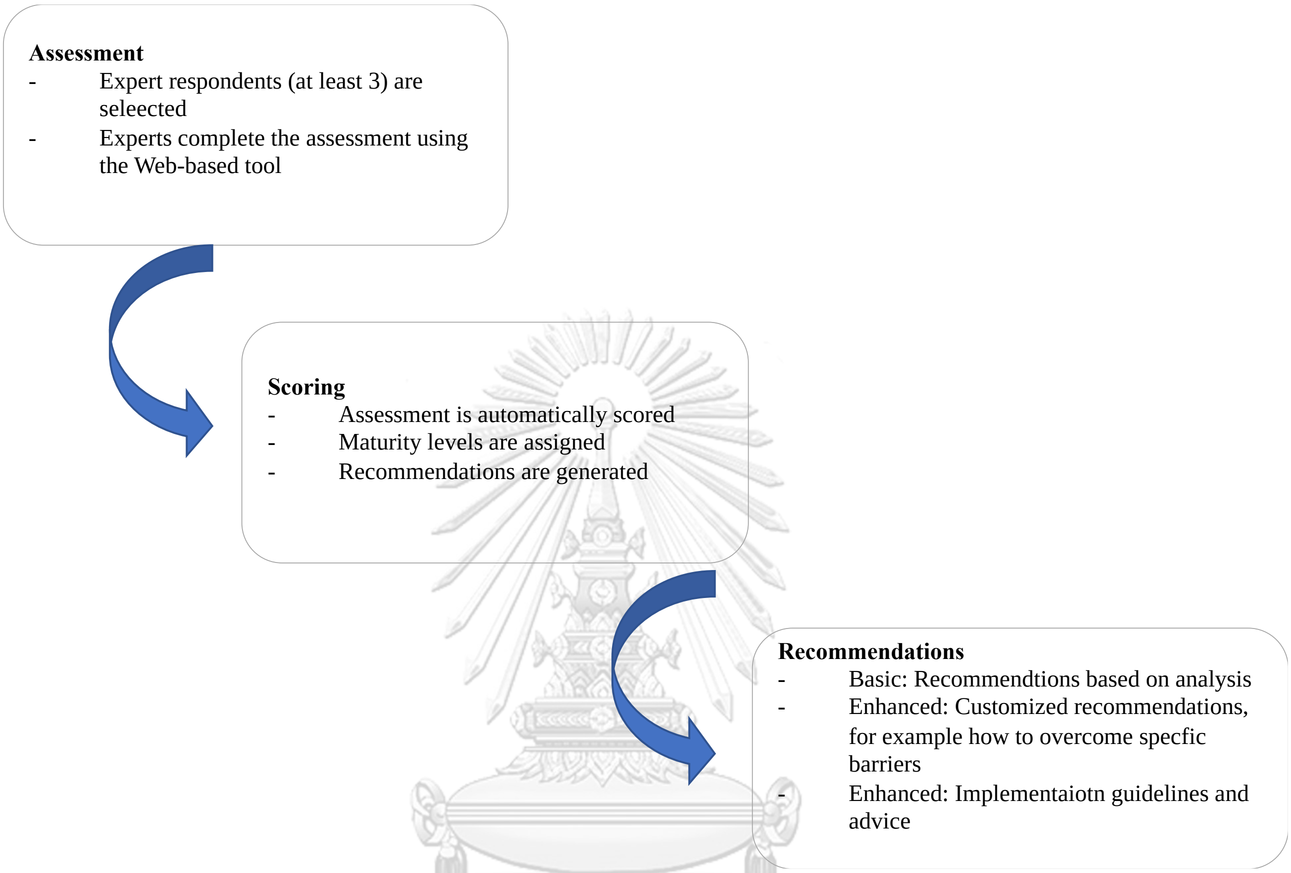


Figure 32 The consulting process

5.2.1.4 Business model canvas

Although the AUIEA framework is not yet fully developed, it is possible to look ahead and consider how this framework can be commercialized in future. The business model canvas framework (Osterwalder and Pigneur, 2013) is used here, as it is designed to facilitate a comprehensive business plan that encourages innovation not just in products and services, but in the business model itself, leading to sustainable competitive advantage. The objective of the business model canvas for the AUIEA framework was to envision a strategy to develop and promote the framework through key business partners and ensure it can reach its target audience of universities in ASEAN. Within the business model, it is presumed that, as in the previous section, the central product is not the framework itself, but consulting services that use the framework via its web-based interface to provide recommendations for innovation framework development.

There are several key partners that will be involved in the development and commercialization of the AIUEA consulting service. The first is established research universities, which can provide assistance and development information to establish how the university innovation model can be used and generate recommendations for its use. Emerging research universities, on the other hand, offer a different kind of insight for development of the consulting service. Specifically, through strategic partnerships with emerging research universities, who are also the main customer base for the product, recommendations can be improved with better knowledge of the barriers and facilitators of implementing a university innovation ecosystem. The ASEAN university network (AUN) will also be a key partner in the development of the consulting service, as it can be used as a source to reach universities and develop connections to potential customers within ASEAN. The National Science, Technology and Innovation Policy Office is the key government partner for the consulting service, as the AIUEA recommendations will be aligned with government innovation policy. Finally private industry partners can provide information about the university innovation networks' reach outside the university environment.

The key commercial activities of the university innovation consulting service is its commercial activities, which include assessment and consulting for university innovation ecosystem development. In order to support these commercial activities, the consulting service will also need to undertake continual framework development, as well as implementation development, in order to improve the underlying framework to continually meet the needs of a changing in the innovation environment.

There are four key value propositions of the university innovation ecosystem consulting service explained here. First it is immediately ready for use and does not require development on the part of the university. Second it is customizable to the specific needs of the university, if the university opts for the enhanced consulting service. Third the consulting services developmental, which means that the results are confidential and are designed for internal use to improve innovation ecosystem development, rather than for external ranking. This provides information about the universities innovation ecosystem, without the pressure of a publicized ranking. Finally the consulting service provides recommendations and guidelines for innovation ecosystem development, based on both academic research into university innovation ecosystems and the growing body of knowledge that is generated from the consulting service itself. These recommendations and guidelines can be tailored to the specific environment of the university, which will mean that these recommendations are of more use than generic recommendations based on other universities.

The customer relationship can be described as a consulting relationship. In a consulting relationship partners work together to generate knowledge regarding the organization’s needs, barriers, and resources, as well as other key information, and then works to solve the problems the organization is facing (Appelbaum and Steed, 2005). Therefore the consulting service will be regarded as an essential partner in the development of the universities innovation strategy, and their relationship is expected to be cooperative, rather than adversarial or competitive. Customers of the consulting service will also be invited to form strategic partnerships, through which the universities can participate in the development of the innovation ecosystem assessment framework and tools. Although no university will be required to participate in this program, this will allow universities to assist in later development and improve the model itself.

The targeted customer segment is research universities in ASEAN. The exact size of this customer base is unknown. It has been estimated that there are approximately 7,000 higher education institutions in ASEAN itself, many of these are not research universities as such, but instead are primarily oriented to teaching. On the other hand, the UN membership of 30 universities does not encompass all universities engaged in active research in ASEAN. The author estimates that there may be between 250 and 750 universities that may be suitable for the consulting service product.

The expected breakdown of expenditures is 20% capital expenditure (CAPEX) and 80% operational expenditure (OPEX). As to specific costs there are three major cost centers anticipated within the consulting service's business model. The first cost centre is research and development (capital expenditure), which is estimated at 20% of total costs. This cost center includes further development of the assessment model and tools, as well as continued development of the web based tool in consulting processes. The second major cost center is consulting costs (operating expenditure), estimated at 50% of costs. This cost center encompasses all costs associated with the consulting process itself including consultants' salaries and bonuses, travel expenses, communication expenses, and so on. The consulting costs are essentially the cost of sales. The third cost center, estimated at 30% of total costs, are the sales and distribution costs (operating expenditure), including the cost of client acquisitions and the cost of the website itself.

Revenues are split between basic consulting services (one-time assessment and auto-generated recommendations) and enhanced consulting services (custom recommendations, long-term or repeated contracts, and innovation implementation consulting). The number of customers for the basic services is expected to be higher, but as these customers will pay less for the services, the relatively smaller number of enhanced consulting services are expected to have a higher customer lifetime value (CLV), both because of their more expensive service provision and because of their choice to continue a consulting relationship (Borle, Singh and Jain, 2008).

The business model framework reveals that the AUIEA does have commercialization potential, but this potential is inherently limited by the small customer segment, which may be difficult to reach due to the limited implementation of university innovation ecosystems. Thus, successful commercialization will depend heavily on the relationship with national innovation agency partners, who can encourage adoption of the AUIEA framework in their partner universities. Furthermore, the AUIEA framework may never have a high financial return, as its development costs may be considerable. Therefore, while the AUIEA framework does have some minor commercialization potential, its transformative value should be considered to be long-term and oriented toward innovation, rather than in terms of direct financial returns.

Key Partners	Key Activities	Value Propositions	Customer Relationships	Customer Segments
- Established research universities - Emerging research universities - AUN - Private industry partners - National Science, Technology and Innovation Police Office	- Innovation ecosystem development assessment - Innovation ecosystem development consulting - Framework development - Implementation development	- Ready for use - Customizable - Developmental - Provides recommendations and guidelines for innovation ecosystem development	- Consulting relationship - Strategic partnerships - Source of development information	- Research universities in ASEAN

Cost Structure	Revenue Streams
Capital expenditure (CAPEX) (20%) Operating expenditure (OPEX) (80%)	Basic consulting services (40%) Enhanced consulting services (60%)

Figure 33 Business model canvas for the AUIEA framework based consultation service

5.2.2 Marketing plan

The marketing plan addresses the marketing environment and key considerations for the marketing practice. As this is a preliminary marketing plan only, the external environment (PESTEL analysis and Porter's five forces) and segmentation, targeting and positioning are the key concerns.

5.2.2.1 PESTEL analysis

The PESTEL analysis (Table 27) is an assessment of the external environment and factors that could affect the adoption of the consulting product. Particularly important aspects of this assessment include the political, social and technological influences, which have combined to move universities increasingly toward innovation as a consideration. Overall, these conditions are positive for the AIUEA framework and the surrounding consulting service, as it suggests that the customer base (universities, particularly research universities) is likely to be highly valuable for the firm.

Table 27 PESTEL analysis for the AIUEA consulting service

Environmental Factor	Conditions
Political	Innovation policy is a key area of government concern in ASEAN countries, especially development of research and development (R&D) capacity and development of national innovation systems (Park and Kim, 2020). Thailand’s National Science, Technology and Innovation Policy Office is heavily involved with international innovation initiatives to address this area of concern, although these policies may not always have a high level of political support (National Science Technology and Innovation Policy Office, 2021). This represents an advantage for the company because universities and other HEAs are becoming more innovation oriented and concerned, and are supported by government policy in developing innovation ecosystems.
Economic	Innovation is a driving force in economic growth, and has been identified as a critical factor in the economic recovery in East Asia as it moves into the near-future economy after COVID-19 (Cirera et al., 2021). This is an advantage for the company, as innovation is a strong concern for industry and industry partners (universities).

Environmental Factor	Conditions
Social	The Asian university sector is undergoing a social shift, including rising enrolment in tertiary education and increasing international profiles of Asian universities (Xu, 2021). This has driven demand for Asian universities from international students and the attractiveness of faculty and research positions within the sector (Xu, 2021). This increasing international profile will drive universities toward international standards for competitiveness reasons, and could increase concern with developing the university innovation ecosystem, representing an opportunity for the company.
Technological	Despite continual predictions of slowing technological innovation, the pace of innovation continues to expand in areas including computing and mobile, medical technologies, and other domains (Driggs, 2020). Therefore, there is a continual demand for new innovators and entrepreneurs. However, over time there is a threat that concern with technological innovation and development as a source of economic growth could slow, or that increasing concern with non-scientific knowledge areas (e.g., social development) could take the forefront. This may require a shift in company strategy to encompass other areas of innovation, such as social innovation, which is not truly addressed by the preliminary

Environmental Factor	Conditions
	framework. To address this threat the company would need to further develop the framework to incorporate these areas of concern, which may require different metrics than scientific innovation. For example, patent filings would likely not be indicative of social innovation.
Environmental	Environmental innovation is another domain of innovation with rapid growth and high demand, particularly in areas like emissions reduction, clean energy, and pollution mitigation and control (European Environment Agency, 2021). While the European Environment Agency (EEA) identifies environmental innovation as a key priority for the European Union, it is also a global priority, including in Asia where there is a strong need to address climate change and environmental pollution in cities (ADB, 2021). This does not have a direct consequence for the framework itself or the company, but is one aspect of innovation that the university innovation ecosystem will be concerned with.
Legal	The main direct legal concern is intellectual property protection of the instrument, which will be protected under copyright law (Aplin and Davis, 2021). More broadly, the university innovation ecosystem is oriented toward production of legally protected

Environmental Factor	Conditions
	intellectual property (IP) within the university. Therefore, the current boundaries and development of IP law will be relevant to the metrics within the model. Although there is no significant shift in IP law anticipated, if such a shift were to occur then the measures and metrics of the instrument may need to be adapted.

5.2.2.2 Porter's five forces

The Porter's (2008) five forces framework is used to consider the competitive environment. A summary of this assessment is provided in Table 28. Within this framework, the biggest challenge is likely to be the buyer's power. As the market is very small and the number of potential customers is low, and because each individual customer may make a significant purchase, the consulting company will need to deal with a relatively high level of buyer power, which could limit the ability to charge. There is also the problem of competitor intensity, since it is possible that other consulting firms may also target this relatively small customer base if the opportunity is attractive. Since there is already a high level of consulting in the educational environment, this is a significant concern.

Table 28 Porter's five forces analysis for the AIUEA consulting service

Force	Conditions
Buyer Power	Buyer power is high. With a small number of large customers, these customers can negotiate better rates through economies of scale (Porter, 2008b). Furthermore, a small number of potential customers limits the market growth potential, although this could be offset through activities such as geographic expansion outside Southeast Asia.
Supplier Power	Supplier power is limited. As the service is primarily a consulting service, the main suppliers are web developers, who are contract companies that can be easily hired. Additionally, there will be

Force	Conditions
	consultants hired for accounting, legal and IP services, and marketing. These companies do have some extent of power in that they could choose to work with the firm or not, but as the consultancies required are all standard business services, it will not be difficult to find one or more suppliers to deliver the necessary consulting services.
Threat of new entrants	Threat of new entrants is moderate. Although new entrants would have some barriers to entry, particularly development barriers, there are no regulatory or legal barriers to entry.
Threat of substitute products	Threat of substitute products is moderate to high. There are already some generic models of university innovation that can be accessed for free (OECD, 2012; National Science Technology and Innovation Policy Office, 2018). Furthermore, as the literature review showed, many universities do choose to develop their own innovation assessments.

Force	Conditions
Competitive intensity	Competitive intensity refers to the overall level of competition within the industry (Porter, 2008b). There is a high level of competition within the consulting industry. An informal survey found that large consulting firms including BCG and McKinsey did offer educational consulting services, including innovation consulting. Thus, there are already firms operating in this market, and new entrants require a competitive advantage in order to enter the market effectively.

5.2.2.3 Segmentation, targeting and positioning

The market segment is defined through a combination of institutional characteristics and needs. Broadly, higher educations in ASEAN can be divided into universities (a high-level institution that focuses on both teaching and research at the undergraduate and postgraduate level) and other institutions (which typically only focus on teaching and research). Furthermore, the consulting service is targeted to universities that have at least a nascent innovation ecosystem and that are pursuing global rankings. As there is no formal definition of such universities, a proxy measure has been developed, which is universities included in the Times Higher Education (2021a) global university ranking that are headquartered in ASEAN countries. These universities are summarized in Table 30. It is possible that a larger market may develop for the product in time, for example including universities that are transitioning toward an entrepreneurial university model or those that are seeking to increase their international standing. As this shows, there are an estimated 27 institutions that are already ranked by the THE, indicating that they are actively developing their innovation ecosystems, and can be considered primary customers. Additionally, some countries including Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam have a relatively large number of universities that may be in the target market, extending the possible market size to about an additional 320 institutions. However, Laos and Myanmar do not currently have any potential customers for the product.

The value proposition UIA Consulting will offer the customer base is: providing an innovation ecosystem assessment tool that is easy to use, easy to understand and explained, confidential and for internal development use. This sets the service apart from competitors through ease of use and confidentiality, which is not guaranteed by other alternatives.

Table 29 Summary of universities in the initially defined target market

Country	Universities
Brunei Darussalam	University Brunei Darussalam
Cambodia	University of Puthisasta
Indonesia	University of Indonesia Bandung Institute of Technology Universitas Pendidikan Indonesia Universitas Airlangga BINUS University Note: there are approximately 90 universities listed in the THE Rankings as ranked/reporters; the five above are the top-ranked universities
Laos	No countries listed as potential target customers at this time

Country	Universities
Malaysia	University of Malaya University Teknologi Petronas Universiti Kebangsaan Malaysia University Putra Malaysia University Sains Malaysia Note: there are approximately 60 universities listed in the THE Rankings as ranked/reporters; the five above are the top-ranked universities
Myanmar	No countries listed as potential target customers at this time
Philippines	University of the Philippines de La Salle University Ateneo de Manila University Note: there are approximately 60 universities listed in the THE Rankings as ranked/reporters; the three above are the top-ranked universities
Singapore	National University Singapore Nanyang Technological University, Singapore Note: there are 9 universities listed in the THE Rankings as ranked/reporters; the two above are the top-ranked universities

Country	Universities
Thailand	Mae Fah Luang University Mahidol University Chulalongkorn University King Mongkut's University of Technology Thonburn Chiang Mai University Note: there are approximately 80 universities listed in the THE Rankings as ranked/reporters; the five above are the top-ranked universities
Vietnam	Duy Tan University Ton Duc Thang University Vietnam National University, Hanoi Hanoi University of Science and Technology Vietnam National University, Ho Chi Minh City Note: there are approximately 20 universities listed in the THE Rankings as ranked/reporters; the five above are the top-ranked universities

(Source of University listings: Times Higher Education, 2021a)

5.2.3 Operational plan

The operational plan is a preliminary assessment of how UIA Consulting can operate as a company. It includes an overview of the value chain and the value added by the firm, the approach to process design, and key issues including the database sharing system and incentive and reward system.

5.2.3.1 Value chain

The service value chain is an adaptation of the product value chain, which can be adapted to the exact business activities and operations of the service firm (Porter, 2008a). The central activities of UIA Consulting are summarized in Figure 34. As this shows, core activities include product development, consulting (service delivery) and sales. The main supporting activity for the company is website development, which will be ongoing as the product is developed.

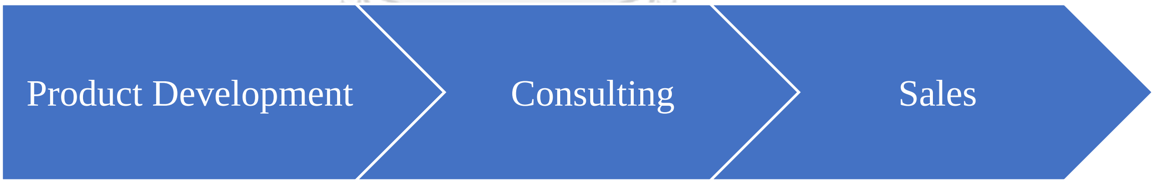


Figure 34 The UIA Consulting Value Chain

5.2.3.2 Process design

The preliminary process design is shown in Figure 35. This process is from the customer's perspective, and therefore represents the key points in customer contact and service delivery. In addition to these processes, there are some back-end processes that are also necessary to support these customer-facing processes. These back-end processes, including recommendation development and model refinement as well as website development, will be ongoing, and therefore may affect the customer process at some points. Additional processes will be designed in more depth when strategic partners have been recruited and are engaged in using the consultancy services and website, since this will be the first opportunity to try the services with live customers. As this figure shows, there is variation between the Basic and Enhanced services, where the Enhanced process will begin with analysis of the customer's needs and establishing a custom plan, while Basic customers will be routed into a standard protocol.

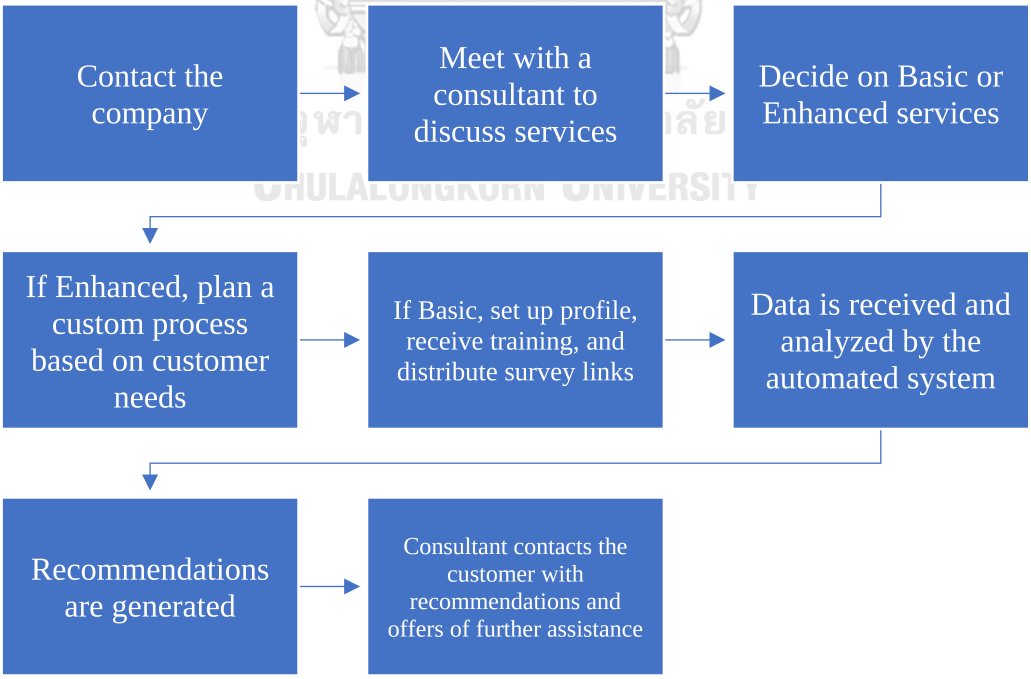


Figure 35 The customer process

5.2.3.3 Database sharing system

One of the major management activities will be development of a database sharing system to allow recommendations to be developed more fully. Use of aggregated data from multiple universities will improve recommendations, as they can be analyzed using text-mining or other artificial intelligence (AI) techniques. Database sharing can also be used manually by consultants to identify opportunities for improvement in the recommendations that are generated. Furthermore, this data could be used by selected outside partners, particularly academics, in researching university innovation practices. Therefore, a database sharing system will be used to allow for limited access for the purposes of legitimate research and analysis. This sharing system will never be used for commercial purposes (not even AIU Consulting's purposes, except for improvement of recommendations), and will not be available to commercial partners. Furthermore, universities must opt in to sharing services. All shared data would be anonymized prior to use. As this does pose a security risk, it is scheduled for later implementation, after the website and IT systems have been shown to have a robust level of security. However, as the database sharing system is a central part of the business process, it is included in the management plan.

5.2.3.4 Incentive and reward system

Consultancy-based services frequently operate based on an incentive and reward system that encourages consultants to maximize performance (Witzel, 2015). In UIA Consulting, consultants will act as the primary point of contact for the service and will therefore also be acting as the main salespeople for the services. In order to incentivize sales effectively, salespeople will be offered a 1% bonus for each Basic project they sell and complete (averaging $50 per project based on the financial projections in Table 32). However, this bonus will rise to 3% for each Enhanced project they sell and complete (averaging $420 based on the financial projections in Table 32). Bonuses are set based on the incentive-based system identified by Witzel (2015) and supported by other authors (Benstead, 2018; Boué & Corradino, 2019). These bonuses are in addition to hourly compensation, and are intended solely both to encourage sales and to promote the use of Enhanced services, which are more beneficial for customers and for the company.

5.2.4 Financial plan

In order to determine whether the AIUEA model is worth developing commercially, a financial feasibility analysis was conducted. This feasibility analysis explains the product, estimates the development costs and potential consulting revenues, and provides a pro forma analysis of the financial position of the university. This analysis suggests that the AIUEA-based consulting service is financially feasible, particularly if it can gain a larger number of customers for the Enhanced service.

Because the AIUEA platform as described here is intended for use in different countries in Asia, there is no single shared currency. In response to this problem, costs and revenues are estimated in US dollars. It can be assumed that there will be an exchange cost associated with the revenues, reported in the income statement, in order to exchange between local currencies and Thai baht (the operating currency of the company.)

5.2.4.1 Planned product

The product and service that will be commercialized is a consulting service, based on the web-based university innovation ecosystem assessment tool. The web-based assessment tool includes the following features:

Secure sign-on using a tool such as Microsoft Live authentication, which associates users with a specific domain (such as university)

An administration tool dashboard that allows innovation administrators to select specific measures, set up monitoring and objectives, and add data for tracking (e.g. the number of patents collected)

Survey tools to allow for data collection on the university process

Reporting tools to allow for ad hoc and customized reporting on the university and innovation hub

The service component of the product is a consulting service, which offers both technical assistance with the web-based tool and enhanced services. There are two levels of consulting planned: Basic and Enhanced.

The Basic level of consulting will include personalized assistance with web tool set-up, including specific objectives and targets, the assessment itself, and a report that generates recommendations for targeted improvements. The Basic service level will be appropriate for universities undertaking a periodic audit of their university innovation ecosystem, as a test prior to engaging in Enhanced consulting, or for smaller universities that want insight into their innovation capabilities. The Basic level of consulting will be a plug and play option that is easy for the users to use and understand, but will not offer detailed analysis and investigation.

The Enhanced level of consulting includes all services at the Basic level, plus customization of the objectives and targets, repeat-measures and/or continual tracking, and consulting services to identify barriers and opportunities to improve the university innovation ecosystem, among other services. The Enhanced service level would be suitable for universities that are engaged in active development of their innovation ecosystems, or which need additional insights and assistance in identifying problems. It would also be suitable for universities that are reorienting to innovation, as it will allow the university to identify a forward path toward a mature innovation ecosystem.

5.2.4.2 Development costs and funding

There are three areas of development cost, including 1) Software development, 2) Website operation and maintenance, 3) Further model development, 3) Consulting program development. These development costs are designed to first establish the website used as the main tool for communication and data collection; to develop and research the rating model for an improved model; and to refine the consulting process. Therefore, it will address all the aspects of the AUIEA model and program development that need to be refined for application to the target market. These areas are discussed in this section, with anticipated costs in Table 31.

Software development. Software development includes development of the web-based application platform, including security and sign-on, administrator dashboard (allowing selection and customization of objectives, KPIs and targets), data collection mechanisms (including direct entry and survey-based entries) and data reporting and monitoring tools. This can be considered a relatively complex app, which has both a high level of customization requirements and high security requirements (to avoid the loss of university information). This development would be done by a contract specialist with expertise in web development, security, and other issues. Therefore, this will be a relatively fixed development cost. Estimates for the cost to build a complex web-based app do vary a lot. One estimate indicates that this could cost $60,000 to $250,000, although outsourcing in less expensive areas can help reduce the cost (Rovnaya, 2022). Another estimation tool suggests that if certain aspects of the development, such as security and sign-on systems, can be integrated from other sources, the project becomes less complex and could be classified as a medium complexity app (Patel, 2021). In this case, the cost would be reduced to $28,000 to $60,000. Given these two comparisons, it can be assumed that the development cost of the web-based app will be around $60,000, as it can be expected to fall between medium and high complexity in the development area.

Website operation and maintenance. Website operating costs include hosting, data storage, and licensing for external tools that are used for the project. Operating costs do not include e-commerce functionality, but would require SSL certificates and storage. Using estimated costs provided by several authors (Patel, 2021; Carney, 2022; Rovnaya, 2022), it can be estimated that operations and maintenance would be approximately $800 per year.

Website maintenance is required to ensure that the website continues to operate efficiently and securely and to implement small changes and minor features. Maintenance tasks for a moderate to complex website can be estimated at $3,000 to $5,000, and is typically time-based (Patel, 2021; Rovnaya, 2022). For this study, it will be assumed the website will have minimal changes after the initial development and will therefore require updates and maintenance for security and technology, but not content. Therefore, $3,000 a year will be used for maintenance.

Further model development. Key issues for further model development include: establishing guidelines for KPIS and performance targets; creating recommendation algorithms and generating recommendations; and testing of the development model through direct application within two to three universities and review of the model with non-university stakeholders (for example commercial and government stakeholders). These objectives can to some extent be accomplished together through an application study with selected stakeholders, including university partners and non-university partners (one to two government agencies and two private sector partners). The application study would include use of the website developed in Stage 1. The estimated costs will be relatively small, but it can be anticipated that there will be some development time and resource requirements involved in the project. It may also be required to offer incentives for participation. The cost for model development is estimated at $10,000, although this is a relatively weak estimate as there is little information about how much similar projects have cost.

Consulting program development. The consulting process and documentation also need to be established, along with training materials for consultants. Additionally, a lightweight knowledge management system (KMS) would be desirable, since KMS allows for the storage and transfer of knowledge between individuals, and can be considered a critical tool for effective product development (Montagna, 2011). The consulting program development will be developed with the software and system development discussed above, and will not require additional funding. The knowledge management program selected, Monday.com, costs $10/month/seat for a standard license (Monday.com, 2022). Therefore, assuming a five-person company to start, the cost for the KMS will be $600.

In summary, the development and first-year operations and maintenance cost is $74,400. At current exchange rates (1 USD = 34 Baht), this is approximately 2.54 million baht, although floating exchange rates means that this may differ by the time of actual expenditure. The first-year operational and maintenance costs are included in the estimate because the project will require up to one year to complete the application test and refine the measurements, objectives, KPIs, targets, and maturity model. Therefore, while these will transition to operational costs (discussed next), in the first year they will constitute development costs. Furthermore, there may be opportunities to reduce the cost of website development through practices such as outsourcing to India or other inexpensive locations for web development, which will be explored if the project is initially viable.

Funding. The initial development cost of $74,400 can be partially funded from the developer's own funds, but additional investment will be required. Angel investors will be sought for the remaining funds, since these investors can provide both additional funds and business advice and connections to improve outcomes (Dat and Anh, 2020). As the developer is prepared to contribute $24,400 to the project (maintaining approximately 32.8% of ownership interest), the additional $50,000 in investment funds (representing 67.2% of share ownership) will be sought from one or more angel investors.

Table 30 Summary of the project's capital and operating expenditures and funding

	Expense	Estimated Cost (USD)	Reference Support
Capital Expenditures			
	Website development	60,000	Patel (2021) Rovnaya (2022)
	Model development	10,000	Author estimate
Total CapEx		70,000	
Operating Expenditures			
	Website operation (first year)	800	Patel (2021) Carney (2022) Rovnaya (2022)
	Website maintenance (first year)	3000	Patel (2021 Rovnaya (2022)
	Knowledge management system (First year)	700	Monday.com (2022)
Total OpEx		4500	
Total First-year Expenditures (Capital and Operating)		74,500	
Funding Requirement		74,500	

5.2.4.3 Pricing strategy and projected sales and revenues

As the product/service being delivered is consulting services supported by use of the AUIEA platform, consulting pricing models were considered to determine an estimated preliminary price. There are several possible pricing models in use in consultancy, of which the most common are hourly, project-based, and value-based pricing (Witzel, 2015). Value-based pricing, in which prices are set by metrics such as profit or cost savings, is used by large consultancies (for example Boston Consulting Group, BCG) when working with for-profit companies (Witzel, 2015). However, as this consultancy service is targeted to a non-financial metric (innovation ecosystem development), value-based pricing would not be appropriate here. Hourly billing is typically used in smaller-scale projects, particularly with very price-sensitive clients (Witzel, 2015). However, in this case it may also not be appropriate given that the projects may vary in time and complexity. At least for the purposes of initial pricing, a project-based pricing is adopted, in which a set price is established based on estimated work for the project. This means that Basic projects will be a standard price, but Enhanced projects may be more or less costly.

To set prices, it is assumed that a Basic project will require 20 hours of consultant time, while an Enhanced project will require 40 hours of consultant time. Assuming a standard rate of $250 per hour, the per-project price for a Basic project will be $5,000. Because the Enhanced project is more complex, it will be estimated at $350 per hour, for a total of $14,000 per project.

A sensitivity analysis under low, medium, and high demand conditions is summarized in Table 32. The low demand condition is based on the assumption that 3% of the potential target customers will adopt the service, while medium demand assumes 5% and high demand assumes 8%. These estimates were based on informal interviews with educational consultants for leading consulting firms, who provided estimated rates for their personal consulting services. (Units were rounded up for calculation.) It is assumed that leading universities will select Enhanced services due to larger size and more complex demands, while other universities will adopt Basic services. This shows that under low demand conditions revenue will be $64,000, while under high-demand conditions revenue will be $390,000. The financial pro forma statement, presented next, was based on the medium demand conditions.

Table 31 Projected sales and revenues under different demand conditions

	Low Demand	Medium Demand	High Demand	Source
Basic services (units)	10	30	50	Informal interviews
Basic services (unit cost)	5,000	5,000	5,000	
Revenue from Basic Services	50,000	150,000	250,000	
Enhanced services (units)	1	6	10	Informal interviews
Enhanced services (unit cost)	14,000	14,000	14,000	
Revenue from Enhanced Services	14,000	84,000	140,000	
Total revenue (USD)	64,000	234,000	390,000	

5.2.4.4 Pro forma income statement and financial feasibility

Pro forma income statements were prepared for the first three years, in order to investigate whether the project will be financially profitable. The following assumptions are made in preparation of the financial statement:

Website maintenance ($3,000) and operating costs ($800) will remain consistent over the first three years

Cost of service is fixed at 15% of sales

Selling, administrative and general expenses, will be not more than 10% of sales

Salaries include one Consultant in Year 1, rising to two Consultants in Year 2 and three Consultants in Year 3

The initial funding of the project will be done using funds from one or more angel investors in addition to the developer's own funds

Cost of capital is 7%

The corporate tax rate is 20% (PWC, 2022)

The income statement (Table 32) shows that the consulting operations would be profitable under average demand conditions (20 basic and 3 enhanced service sales), achieving a profit margin of 29% in Year 1. This would rise to 36% in Year 2, and rise slightly more to 43% in Year 3. Overall, therefore, the project can be considered as financially viable purely from a profit perspective if the project can achieve average demand conditions. If it cannot, there are cost-saving measures that could be taken, such as eliminating the Coordinator role or reducing Consultant hours to part-time, which will save on the main cost center of salaries.

Table 32 Pro forma income statement (Years 1 to 3)

AIUEA Web Tool

Three-year Pro Forma Income Statement

	Year 1 (USD)	Year 2 (USD)	Year 3 (USD)
Units sold (Basic)	20	30	50
Cost/unit (Basic)	5,000	5,000	5,000
Units sold (Enhanced)	3	6	10
Cost/unit (Enhanced)	14,000	14,000	14,000
Revenues	142,000	234,000	390,000
Cost of sales (15%)	21,300	35,100	58,500
Gross profit	120,700	198,900	331,500
Operating expenses	3,800	3,800	3,800
Sales, general and administrative expenses (10%)	14,200	23,400	39,000
Salaries	46,800	61,200	75,600
Operating profit	55,900	110,500	213,100
Interest expense	5,000	5,000	5,000

	Year 1 (USD)	Year 2 (USD)	Year 3 (USD)
Income before taxes	50,900	105,500	208,100
Income taxes (20%)	10,180	21,100	41,620
Net profit	40,720	84,400	166,480
Net profit margin	29%	36%	43%
	Year 1	Year 2	Year 3
Notes			
In Year 1, the low-demand conditions hold. In Year 2, this rises to medium demand, and in Year 3 it rises to high demand			
Cost of sales is 15% of gross revenues			
SA&G expenses is 10% of gross revenues			
Cost of capital (interest) is 7%			
Corporate tax rate is 20% of pre-tax profits			

Financial feasibility was also investigated using measures including payback period (PP), net present value (NPV), and internal rate of return (IRR). These figures were calculated in Excel using the financial projections as the basis. These measures are summarized in Table 35. The measures were calculated using the initial capital investment ($74,400), the assumed 7% cost of capital, and the net profits estimated in Table 33. This assessment shows that the project will be moderately profitable. The initial payback period will be one year and 4.8 months. The NPV of $161,936 indicates that the project will have a positive net return when accounting for the time cost of money. Furthermore, the IRR of 83% indicates that the project will have a positive net cash flow.

Table 33 Financial feasibility measures (in case of most likely)

Initial investment		$74,400
Payback period (PP)	1 year, 4.8 months	
Net present value (NPV)		$161,936
Internal rate of return (IRR)		83%

5.2.4.5 Summary of feasibility assessment

The feasibility assessment incorporated a description of the product to be commercialized, the estimated development costs, the projected revenues, and pro forma financial statements and financial feasibility estimates. Both the financial statements and the financial feasibility measures indicated that this project would be financially feasible. Furthermore, the estimated development cost of $74,400 is not highly dependent on the sales volume, indicating that higher sales could actually improve these figures. Overall, therefore, the estimated development costs and revenues do indicate that developing the AIUEA assessment tool as the central core of a consulting service aimed at universities developing their innovation ecosystems is financially feasible.

5.3 Implementation Plan

The implementation plan is summarized in Figure 36. This implementation plan is split into two stages. In the short term, the immediate objective is to collaborate with an institution such as AUN, to develop awareness of the AUIEA model and promote it as a credible choice for assessing university innovation ecosystems. In the long term, the commercialization of the project requires implementation of a website to both promote the AUIEA assessment model and allow universities to actually use the model in internal assessment. The website will also require testing, both for its technical capabilities and security and for its usability. The implementation plan is staged across two periods: Short-term (the first six months of implementation) and long-term (the second six months of implementation). During the short-term period, the focus is on partner selection and promotion of the service and model through AUN. This period will allow the resources needed for the implementation stages during the second half of the process. During the second half of the implementation period, the website and framework will be fully developed through active testing with strategic partners, who will be universities selected at a variety of different needs and levels. This will include at least one Basic and one Enhanced service, enabling the workflows for both consultation processes to be tested. At this stage the promotional activities will proceed to active marketing, to ensure that customers are ready to use the service on launch.

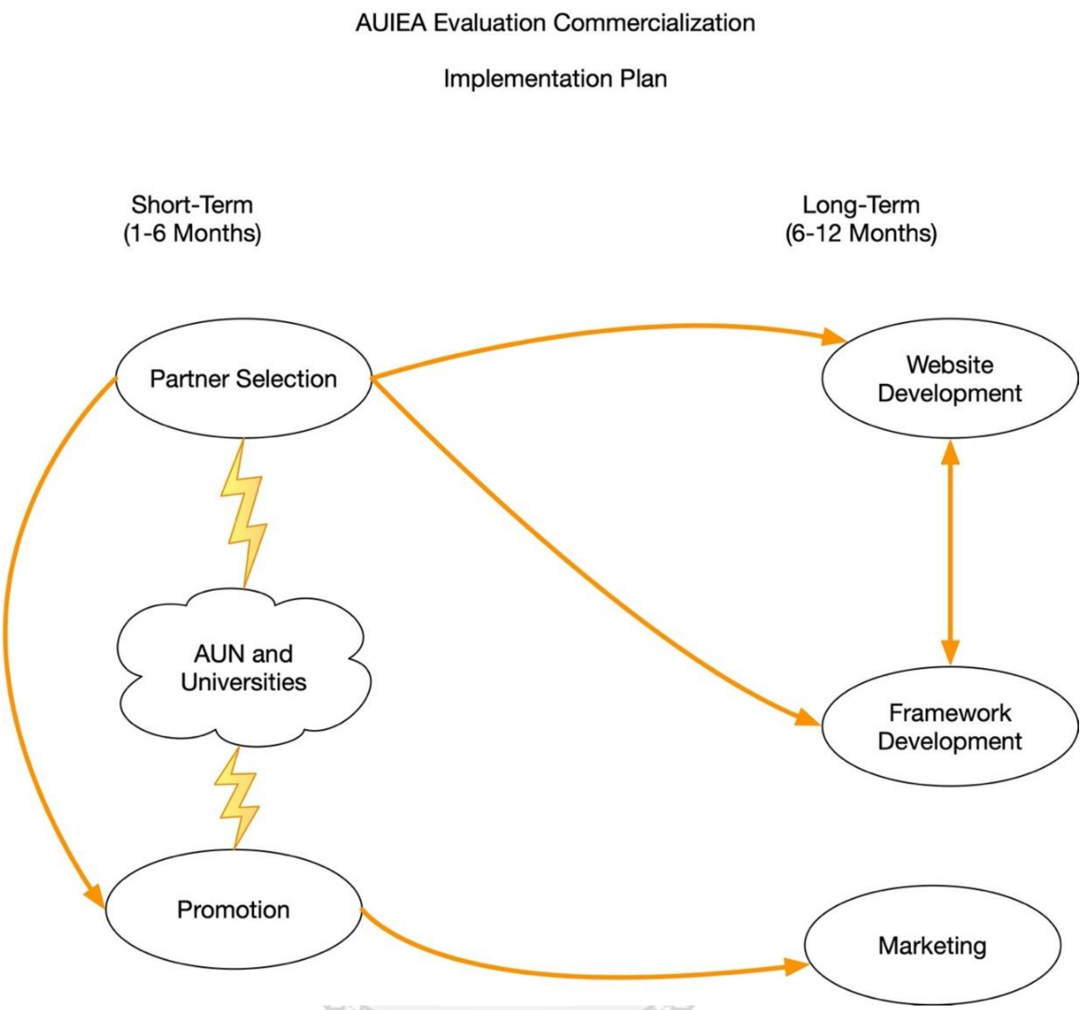


Figure 36 Implementation plan

5.4 Risk Management

There are some risks associated with the project, as summarized in Table 34. A likelihood-impact risk matrix was constructed to evaluate the potential impact of the risks. This shows that the biggest risk is failure to gain customers among universities in Southeast Asia, which would essentially make the project unviable. To offset other potential risks that would have less impact include the potential for university data loss and the lack of availability of suitable consultants.

Table 34 Summary of the risk assessment for the project

Risk	Likelihood	Impact	Weighted Risk
Failure to gain customers among universities	2	5	10
Failure to find qualified consultants	1	4	4
Data security breach leading to loss of data	3	3	9
IP challenges (e.g. copyright violations)	4	2	8
Reputational risks (e.g. company/brand reputation)	1	3	3

Note: Likelihood – 1 very unlikely; 2 = unlikely; 3 = slightly likely; 4 = very likely; 5 = inevitable
Impact – 1 = negligible; 2 = minor; 3 = noticeable; 4 = major; 5 = catastrophic

A mitigation strategy has been developed for the top three identified risks. The mitigation strategy for the top risk (failure to gain customers) is to reduce this potential risk by seeking out universities as strategic partners prior to investment. This will help ensure that the project has some established relationships and partners prior to the implementation. To offset the risk of data security breaches and data loss, the web development project will use high-level security and two-factor authentication tied to existing Microsoft Live accounts. To offset the risk of consultant availability, various benefits such as remote working and the potential for incentives (discussed previously) will be provided. These mitigation strategies will be developed more fully in the full business implementation, as they will be dependent on formation of strategic partnerships.

5.5 Chapter Summary

This chapter began with a review of the website development process and considerations for the AIUEA assessment tool. The review showed that the website itself will offer an easy to use and accessible tool which applies the assessment instruments and rubrics developed in the research (presented in Chapter 4) to visually depict the university's current innovation ecosystem development and provide recommendations for areas of improvement. The website will need special attention to issues of data privacy, particularly since the assessment evaluates sensitive information and respondents who provide data require strict confidentiality while still being able to validate their inclusion in responses.

This chapter has also reflected on the applications and approach to commercialization for the AUIEA framework. The main application that is considered for the framework is a developmental application – in other words, not to rank university outputs as such, but to examine the progress the university is making against set performance indicators and identify opportunities for improvement. This is a crucial distinction because it helps to differentiate the AUIEA framework from other commercialized ranking approaches, such as those used by the QS World University Rankings and Times Higher Education rankings. The business model canvas developed to commercialize the AUIEA framework follows this intended application. It emphasizes key partnerships including universities and government agencies to encourage adoption and application of the AUIEA framework. The financial plan also estimated that $74,500 was required to launch the program, including funding for capital expenditures of $70,000 for website and model development and $4,500 for website operation and maintenance and the knowledge management system.

As noted in Chapter 4, there is still some development needed before the AUIEA framework is fully prepared for commercialization. For example, the AUIEA framework needs to be tested through application in one or more universities or other higher education institutions and formal assessment instruments and processes need to be developed. In Chapter 6, the initial process of website development is discussed, as this is the next stage in the development process. Further steps in the research and development process, along with other aspects of the conclusion, are detailed in Chapter 7.

CHAPTER VI
CONCLUSION AND RECOMMENDATIONS

The previous chapters of this research have each addressed a different aspect of the study. In Chapter 1, the researcher set the objectives and scope of the study. The literature review in Chapter 2 established a theoretical background for the study, while in Chapter 3 the primary research methodology and design was explained. Chapter 4 presented and discussed the findings, culminating in the final AUIEA model and the validation study that supported its commercialization potential. Chapter 5 addressed the commercialization of the AIUEA assessment through a web-based consultancy service, addressing the web design issues and the management, marketing and operational plans. The objective of this chapter is to bring together these different aspects of the study, providing a final conclusion to the research and reflection on its outcomes. The chapter begins with a conclusion that answers each of the research objectives. The practical applications and academic implications of the findings are discussed next. The research limitations are considered. Finally, recommendations for future research are presented, both for the current research and for other researchers.

6.1 Discussion and Conclusion

6.1.1 Discussion

The starting point of this research was several university innovation ecosystem models that had been developed by previous authors, typically for application within a specific university setting (Kirby et al., 2011; Guerrero and Urbano, 2012; Brennan et al., 2014; Guerrero et al., 2014) or for broader application (OECD, 2012; National Science Technology and Innovation Policy Office, 2018). These models were typically constructed based on commercial innovation models, and did not address the institutional innovation context or goals (Bessant and Tidd, 2015). Throughout the course of this research, the initial input of these models was developed, refined and tested to develop a broadly applicable university innovation model that considered not just the external context and norms of commercial innovation, but the policies, activities, and relationships through which knowledge of scientific and commercial value is produced in the university. Thus, this model represents a significant expansion of academic knowledge on university innovation ecosystems, which addressed one of the critical research gaps that was identified in the study.

The application and commercialization stages of this research also constitute a significant contribution to innovation policy and practice in the university setting. Previous university innovation ecosystem models, such as that developed by Guerrero and Urbano (2012, 2014, 2016) and OECD (2012), have been designed for application in the university environment, but details on how to apply these models is in large part left up to the university. Thus, while universities could use these tools internally, they would need to apply and make their own inferences about the model's outcomes. Furthermore, many of the models did not have detailed scoring systems or items, but were rather based on broad policy statements or crude metrics like the number of patents issued. This research showed that these policies could be difficult for universities to use when the university innovation ecosystem was still developing, rather than already in place. The application of a maturity model approach based on the CMMI (Constantinescu and Iacob, 2007) was intended to overcome this limitation of previous models, by viewing the innovation ecosystem as a dynamic work in progress, rather than a static, finished phenomenon. This dynamic capability maturity model improves the usability of the final model because it allows universities to not just identify their current state of innovation ecosystem development, but also to map their forward progress with specific areas for improvement. Therefore, the commercialized model fills a gap for universities that cannot be filled using the existing tools on the market.

One of the assumptions of earlier university innovation ecosystem models is that innovation is viewed as central to the university's mission and that it can be measured using final outputs like patents. This is problematic for universities in Asia, which have lower patent issuance than Western universities (Fisch et al., 2015) and lower overall development of the university innovation ecosystem model (Singh et al., 2015). This does not necessarily mean that universities in Asia are not innovative, however! The Western concept of the 'third mission' (Brennan et al., 2014) as a commercial remit simply may not be universally applicable. For example, Asian universities may be more focused on community involvement or relationship building, which are also part of the third mission (Brennan et al., 2014). This is a question that would be useful for future authors to investigate, since it may be one of the key philosophical differences between Western and Asian universities. Overall, this research has contributed by developing a university innovation ecosystem model that reflects the needs of Asian universities who are still integrating innovation into their university objectives, and who may not prioritize innovation as the sole or primary mission of outward engagement.

There are some remaining issues that need to be addressed, as they could not be resolved through the primary analysis. The three core issues include the potential multidimensionality of the Leaders and Governors and Innovators constructs, the elimination of the Agents of Change dimension and the seeming disconnection of the Entrepreneurial Hub construct.

The first key issue was the dimensionality of the Leaders and Governors and Innovators constructs within the model. Although the first-order constructs in both of these constructs displayed adequate factor loadings on the second-order construct, there were some weaknesses in the internal structures and relationships of the first-order constructs themselves. This was part of the reason for conducting the nomological testing, in order to determine whether the proposed factor structure could be improved. The reason for this potential dual role can be seen easily in the literature on Innovators, as the Innovator role includes both those producing innovation (for example researchers) (Coyle, Gibb and Haskins, 2013).

And those that facilitate innovation and commercialize innovations produced in the university (for example the innovation hub and/or technology transfer office) (Bradley, Hayter and Link, 2013). It also encompasses a wide variety of activities, including direct research and researcher-firm and university-industry partnerships (Plewa et al., 2013; De Jager et al., 2017), even establishment of spin-offs to commercialize innovations (Lubik et al., 2013). Thus, it can be seen that there are at least two entirely different kinds of activities encompassed within a very broad Innovators second-order construct. Thus, there really is a potential theoretical and practical reason to split this dimension into two sub-dimensions, to better reflect what are two different kinds of activities with different facilitating conditions and needs.

The second key issue relates to the Agents of Change dimension, which was ultimately eliminated from the assessment model. The Agents of Change dimension was originally adopted from the Thailand National Science, Technology and Innovation

Policy Office's (2018) university innovation model, which was used as the preliminary framework for this research. Its inclusion was supported by other models which also included change agents in their assessment of the university innovation ecosystem (Guerrero and Urbano, 2012; Brennan et al., 2014). Several other researchers supported the inclusion of change agents, pointing out that change is a necessary process for university innovation (Sęk, 2017; McConnell and Cross, 2019). The literature also pointed out that Agents of Change, including managers, educators and faculty members, and others, are critical for the organization's acceptance of change (Brennan et al., 2014; Ortiz-Medina et al., 2016; Galan-Muros and Davey, 2019; Koiwanit et al., 2019; Wakkee et al., 2019) although some groups such as students and contingent faculty may have limited capability to act for change (Hongjuan, 2018; Drake et al., 2019). Thus, inclusion of an Agents of Change dimension was not unwarranted, and in fact the participants in the Delphi study did not discount their importance. Instead, the argument for exclusion that supported the lack of consensus was that any of the other four roles could act as Agents of Change, and that there was a need to disambiguate these roles. In other words, the Agents of Change role was important, but it was also subsumed in other roles. Thus, even though there is no explicit Agents of Change role in the final model, the importance of change is still reflected in the remaining roles and measures.

The final issue was the lack of reliability identified in some of the first-order constructs of the Leaders and Governors role, which was found during the nomological testing. In addition to the inconsistency between first-order dimensions, suggesting Leaders and Governors may be more correctly modelled as two constructs, there was a high degree of variance in factor loadings in the Stage 3 expert survey compared to

Stage 2. This suggests that the underlying construct is not reliable – that is, that experts in different cultures have different ideas about the role of the Leaders and Governors constructs. This was actually one of the motivating reasons for the research, since as prior studies have all been conducted in Western countries and institutions, there is a lack of understanding of innovation in the Asian university. Fundamentally, this could point to a difference between different institutions and countries in the role of leadership and institutional communication, direction and control (Blaschke et al., 2014). It could also point to a difference in the role of the so-called third mission of innovation in the university between cultures (Loi and Di Guardo, 2015). A comparative study between different countries to understand the role of leadership in innovation may be justified to resolve this issue.

In summary, it is clear that there is still some work to be done to improve the reliability and validity of the measurement model, in order to improve the dimensionality of two measures and address the lack of construct validity and reliability of the Leaders and Governors role and its associated measures in particular.

6.1.2 Conclusion

There were four objectives set for this study in Chapter 1. These objectives included, in brief:

I. Developing a preliminary framework for university innovation ecosystem assessment;

II. Testing and refining the preliminary assessment framework;

III. Evaluating the nomological validity of the refined framework;

IV. Developing an approach for commercialization of the final model.

There are five key processes involved in achieving these objectives, which were reported in Chapter 2 (literature review), Chapter 4 (primary research) and Chapter 5 (commercialization). These objectives, cumulatively, resulted in the development of the Asian University Innovation Ecosystem Assessment (AUIEA) framework. A review of the key outcomes for each objective is as follows.

Objective 1. Objective 1 was accomplished through a combination of literature review and a Delphi study. The literature review, reported in Chapter 2, culminated in the development of a preliminary theoretical framework in which the university innovation ecosystem was conceptualized as a set of role-based processes and activities. Five roles were proposed, including Leaders and Governors, Educators, Innovators, Connectors, and Agents of Change. A preliminary instrument was developed using a wide range of potential items from the literature review, which was subjected to a Delphi study of university innovation experts from the ASEAN+3 countries (n = 40). The outcome of the Delphi study was a preliminary framework consisting of 91 items, arranged across 21 individual process/outcome measures in four role-based dimensions. The only role eliminated was Agents of Change, which overlapped completely with other roles.

Objective 2. Objective 2 was accomplished using an expert survey of university, government, private sector and third sector (non-profit and NGO) experts in the ASEAN countries (Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam, China, Japan and Korea) (n = 418). The survey used the preliminary framework and items developed in the Delphi study conducted to meet Objective 1, with a scenario approach used to investigate which measures experts associated with innovation. A process of confirmatory factor analysis (CFA) was used to evaluate the measurement model for each of the four roles, and where necessary remove unrelated items in a model reduction process. This resulted in a refined framework, which measured the constructs using 64 items. Finally, the maturity model and how it can be applied was developed, showing how the AUIEA model could be used to identify broad areas for improvement and understand the institution's overall level of innovation ecosystem implementation maturity.

Objective 3. Objective 3 was accomplished using a second expert survey, this time drawing from a wider sample of innovation experts across the Asia Pacific region (n = 459). Confirmatory factor analysis was used for two purposes – to investigate the measurement model and association of first-order and second-order constructs, and to determine whether the model was reliable in a slightly different sample. The analysis showed that there could be some improvements in the model structures, including potentially splitting the Leaders and Governors and Innovators second-order constructs into smaller constructs. The comparison of the first and second expert surveys also showed that although results for Educators, Innovators and Connectors were similar, there were some inconsistencies between samples in the Leaders and Governors role dimension. This indicates that the AUIEA framework does require additional testing and development. These opportunities are discussed in the following sections.

Objective 4. The final objective was accomplished using a combination of critical reflection to identify points of differentiation and a market gap and the business model canvas. Results are presented in Chapter 5. The service developed for commercialization of the AIUEA framework is a consulting service, which builds on the web-based framework and rubric to provide targeted assessments and recommendations for development of a university's innovation ecosystem. The first steps toward commercialization were taken in Chapter 5, in which the plan for developing the website and consulting service for the AIUEA assessment tool are presented. Here, a preliminary business plan is developed which sets out what UIA (University Innovation Assessment) will do and how it will do it. As described in the business plan, the AIUEA model will be marketed as a consulting service, with two levels of service allowing universities to assess their internal ecosystems. The planning also included vision and mission statement, operational plans, and financial plans among other information.

In conclusion, this study has been successful at achieving the objectives it set out to accomplish. There are some implications of the findings for both practical application and academics, which are considered in the following section. Furthermore, there are some areas where findings are limited, and where more research is needed for full development of the AUIEA model and in general for the academic study of university innovation ecosystems. These are discussed later in the chapter.

Table 35 Key findings summary

Research Objective	Research Question	Methodology	Findings
1. To develop a preliminary framework for university innovation ecosystem assessment based on existing theories and models and expert insights.	RQ1.1 What are the characteristics and features of existing university innovation ecosystem assessment models, and how do they apply to Asian universities?	Literature Review	A theoretical model of university innovation ecosystem assessment was developed. Little study has been conducted in Asian universities.
	RQ1.2 What is the expert consensus on the innovative university in ASEAN?	Delphi study	An expert consensus identified a preliminary model including four dimensions (Leaders, Educators, Innovators, and Connectors), 21 sub-dimensions and 91 individual items.
2. To test and refine the preliminary assessment using insights from university innovation experts in the university itself and in partner organizations including governments, non-governmental organizations (NGOs) and private enterprise in ASEAN.	RQ2.1 What are the dimensions of the university innovation ecosystem? RQ2.2 What are appropriate measures to assess these dimensions?	Expert survey Confirmatory factor analysis (CFA)	A refined model, which included 64 items across the model was confirmed.
3. To evaluate the validity of the nomological network of constructs and relationships and investigate the validity of the proposed framework in the Asia Pacific region.	RQ3.1 To what extent does the university innovation ecosystem assessment model developed in Objectives 1 and 2 apply in the broader Asia Pacific context and across different samples?	Nomological testing Expert survey CFA	Nomological testing confirmed the factor structure and validity of the finalized measurement model, now called the AIUIA model.
4. To develop an approach for implementing and commercializing the model that results from the research.	RQ4 How can the university innovation ecosystem assessment model derived in Objectives 1 to 3 be commercialized and distributed for use in Asian universities?	Qualitative analysis Content analysis Triangulation	The finalized AIUIA model has small-scale commercial potential, but requires additional development and feasibility testing.

6.2 Implications

6.2.1 Practical and commercial applications

This research was undertaken with the intention of developing a practical framework for university innovation ecosystem assessment that could be developed as a commercial application. This was accomplished to some extent, but as more research is needed in the development of the AUIEA model before it is ready for commercialization and use, its application is not directly recommended. However, there were some lessons learned that could be applied by university leaders and policymakers in the meantime, which could improve their institution’s innovation performance.

The first practical implication, which is indicated by both the systematic AUIEA framework and its antecedent models, is that effective innovation at the university level requires a systematic integration of the principles of innovation and entrepreneurship at all levels of the institution. While many researchers may gauge their innovation contributions by the work of their leading researchers, in fact the long-term and sustainable effect of the innovative university is in its promotion, teaching and encouragement of the next generation of innovators as much as the current innovation and commercialization activity. This means that innovation needs to be embedded not just in the research activities of the organization, but in the educational practices, policies and strategies of the university. Such policies, strategies, and teaching curriculum and practices ensure that innovation is at the heart of the university's activities an how it is oriented.

The second practical implication relates to the measurement of innovation activities in the university. The AUIEA framework is based on the premise that, especially during earlier stages of innovation network development, what the university is doing to promote innovation may be as important as its outputs. Fundamentally, the outputs of innovation activity – research, intellectual property applications and grants, and commercialization activities like spin-offs and licensing – take time to develop. By measuring processes of innovation, not just outputs, universities can track their progress toward an innovation ecosystem while it is developing and identify opportunities for improvement. Thus, regardless of the exact model for innovation assessment is chosen, a combination of process and outcome measures is appropriate for most universities.

6.2.2 Academic implications

This research has contributed to the academic literature by developing a process-oriented framework for evaluation and assessment of the university innovation ecosystem. This framework is different from others which have been developed in

Western university contexts and in established research universities in several ways. Perhaps most importantly, the AUIEA model is designed for development of a university innovation ecosystem rather than assessment and ranking of established university innovation ecosystems. This means it is suitable for considering how university innovation ecosystems emerge and develop, not just how they can be measured in cross-sectional time. It also includes both formal and informal network connections at all levels of the organization, from student research to university policy. At the same time, the AUIEA model can be generalized as it is not tied to any specific university policy or set of organizational practices. This is distinct from any previous assessment framework for university innovation that has been developed to date. Although the primary application of the research is commercial, as noted above, these features of general rather than specific measures, formal and informal measures, and developmental and process-oriented measures could mean the AUIEA framework is also a useful analytical tool for other researchers working in the field of university innovation. Thus, this is an important contribution to the research. However, as will be discussed below, there are still some areas where more research is needed to address limitations.

6.3 Research Limitations

There are several limitations to the findings, including both their extent and their generalization. The biggest limitation to the findings is that although the research process as designed was completed, the final stage of nomological testing showed that there were still some weaknesses in the proposed model structure and relationships of the framework, as well as potentially in the reliability of the instrument. This indicates that the AUIEA framework requires additional research and testing to be considered fully reliable and valid, and thus ready for commercialization.

There are also some potential limitations to generalization of the AUIEA framework. The AUIEA framework was specifically intended to measure processes and institutional conditions that facilitate university innovation ecosystem development, rather than focusing on innovation outcomes as most other models do. (While innovation outcomes were included for some measures, these are not typically the only or even the majority of measures.) While this makes the AUIEA framework appropriate for institutions that are beginning to implement or develop their innovation capabilities and internal and external networks of innovation, it may be less effective as a developmental tool for universities where the innovation ecosystem is well-developed. Furthermore, because the AUIEA framework was designed in the specific context of Asian universities, it may not apply outside this geographic area. While the model could be used as a general guideline for institutions in other regions, doing so should be accompanied by a critical reflection on the model, and its utility for the institutional and organizational context of innovation.

6.4 Recommendations for Future Research

There are two areas where recommendations for future research can be identified. The first area is within the AUIEA framework itself. The second area is in the domain of university innovation ecosystems and measurement.

There were several issues identified with the AUIEA framework itself that need to be resolved before it would be feasible to commercialize the framework. First, the issues of reliability and validity must be resolved. This includes, for example, investigating the factor structure of the Leaders and Governors, Innovators and Connectors dimensions to determine whether the first-order constructs could be more effectively organized into other or more second-order constructs. The Leaders and Governors role and its constructs must be particularly investigated, since it demonstrated a lack of measurement reliability between the two expert samples. There is also additional research that needs to be done to support the commercialization of the AUIEA framework as it is envisioned – a turnkey developmental assessment tool for universities. This additional development work includes establishing specific KPIs for each of the measures and an implementation guideline that will enable universities to choose appropriate KPIs and design and implement evaluation and monitoring systems. It also includes further research to establish a maturity model framework to assist institutions with developmental objectives and strategies. The researcher intends to undertake this additional developmental research, in addition to the preliminary maturity model as developed in Section 4.4. The final area for development within the AUIEA model itself is addressing the Agents of Change dimension. This dimension was eliminated from the initial model following the Delphi study, as there was no expert consensus that the Agents of Change dimension was distinct from the other dimensions.

However, it is possible that this dimension simply requires refinement of the measurement items to more clearly distinguish the Agents of Change dimension from other dimensions; for example, the Leaders and Governors (L) dimension, where many of the initial Agents of Change items were assigned. This dimension also requires a stronger theoretical foundation than could be established here. Thus, it is possible that the Agents of Change dimension could be re-incorporated into the model in future study.

There are also opportunities that have been identified that could be taken up by other researchers. One of the questions that cannot be clarified through the literature is, how universal *is* the concept of the university innovation ecosystem? The existing literature makes it clear that there is no consensus definition or model for university innovation ecosystems, and in fact there has been no effort to establish such a consensus definition. Instead, most extant models were developed for a single university. Thus, the concept itself has not moved much beyond the individual case study level of research. This offers an opportunity to conduct cross-organizational research to better understand and theorize about university innovation and its supporting systems. Such research, which could for example use comparative or multiple case studies followed by broader survey research, could result in a much better theory of the university as a context for innovation and how it differs from other contexts, such as the private sector, which have been more widely investigated.

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APPENDICES

Appendix A: Delphi Study

Thank you for agreeing to participate in the Delphi study. This study is intended to investigate and develop a consensus regarding the performance measurement of university innovation ecosystems in Asian universities. The ultimate goal is to develop a performance measurement tool that universities can use to guide and assess their innovation ecosystem development in accordance with national and institutional objectives and their current position.

The study will consist of three rounds. In Round 1 (Exploration), you will be shown a series of potential assessments of university innovation ecosystems. You will be first asked whether this assessment statement is an appropriate measure of the university's innovation ecosystem. Next, you will be asked to classify the assessment statement in one of five broad functional categories of the university innovation ecosystem. These categories are actor-based, so please classify items based on the actor you think holds the primary responsibility for the assessment statement. The actor groups include: Leaders, Educators, Innovators, Connectors, and Agents of Change.

In Round 2 (Development), you will be shown the refined assessment statements which were derived from Round 1. This will include a slightly different set of statements, as it will include the statements that were proposed in Round 1 and exclude those where there was no consensus in Round 1. In this round, you will be asked first to confirm that the item should be included in the assessment model and whether it belongs in its assigned actor category. You will then be asked to assign it to one of several functional categories, which relate to what the assessment statement is intended to support.

In Round 3 (Confirmation), you will be presented with the assessment items developed in Round 2, including their actor and functional placements. You will be asked to confirm or reject the item and its categorical placements.

These instructions will be repeated at the beginning of each round, along with more detailed information about survey completion. Please send any questions or comments to me at:

[Researcher Contact Information]

Round 1 (Exploration)

For each item:

1) Should this item be used to measure university innovation ecosystem performance? [Yes/No]

2) Which of these actors has the primary responsibility for this item? [Leaders, Educators, Innovators, Connectors, Agents of Change]

Actor Dimension	Proposed Items
Leaders (31)	The university has a flexible organizational structure. The university’s culture centralizes/prioritizes innovation and entrepreneurship. The university leadership actively promotes and supports innovation and entrepreneurship. University policy is oriented to innovation and entrepreneurship. There are clear policies to facilitate innovation in the university. University innovation policies emphasize the importance of STEM. There are clear policies to facilitate entrepreneurship in the university. There are clear policies to facilitate innovation and education entrepreneurship. There are short-term objectives (under one year) in place to facilitate university innovation and entrepreneurship. There are medium-term objectives (one to five years) in place to facilitate university innovation and entrepreneurship. There are long-term objectives (five years or longer) in place to facilitate university innovation and entrepreneurship. There is a monitoring mechanism in place to facilitate university innovation and entrepreneurship objectives. There is a performance measurement mechanism in place to facilitate university innovation and entrepreneurship objectives. University innovation strategy meets short-term objectives. University innovation strategy meets medium-term objectives. University innovation strategy meets long-term objectives. University innovation strategy is routinely successful. University staffing is oriented toward innovation and entrepreneurship. When recruiting university educators and researchers, innovation performance is a key recruitment criterion. Academic and research staff are selected in part for their expertise in innovation and/or entrepreneurship in their areas of specialism. The university budget includes adequate funding to support innovation and entrepreneurship. The university has financial and technological resources available to facilitate innovation by students, early career researchers, and others without external or independent funding. The university’s resources are distributed fairly among innovation actors. Members of the university (including administrators, staff, educators, researchers, and students) have access to sufficient resources for their education and innovation activities.

Actor Dimension	Proposed Items
	There is a mechanism in place to manage resource conflicts when required. There is a review board or other mechanism to review assignment of resources and deal with resource conflicts. Innovation at the university considers multiple stakeholders, including people and the environment. There are clear mechanisms in place to ensure prioritization of key stakeholders. There are specific policy objectives for stakeholder engagement. Stakeholder representatives are actively recruited for participation. There is an organized stakeholder interest group (such as an oversight board) that plays a formal role in innovation activities. Community stakeholders are centralized in innovation policy. University innovation activities draw on a wide range of stakeholder perspectives. Stakeholders are consulted as appropriate depending on their interest in innovation. Stakeholder engagement can be considered successful. University vision is oriented to innovation and entrepreneurship. University vision is clearly communicated in materials and policy. University vision specifies purposes for innovation. University vision considers innovation as a sustainable activity. University vision for innovation is incorporated into policies and strategies. University vision for innovation is translated to university innovation policies. There are performance measures associated with the university vision.

Actor Dimension	Proposed Items
Educators (24)	Educators have positive attitudes toward innovation. Educators take responsibility for students' innovation. Educators act as innovators themselves. Educators in non-STEM disciplines have an interest in innovation and entrepreneurship. There are processes available for educators to gain access to resources for innovation and entrepreneurship activities. Educators form connections outside the university for innovation and entrepreneurship activities. The university has an established teaching program for innovation and entrepreneurship studies. Principles of innovation and entrepreneurship are integrated into curriculum areas throughout the university. Innovation and entrepreneurship learning opportunities are available to all students, regardless of academic discipline. STEM degree courses place emphasis on innovation and entrepreneurship. Non-STEM degrees place emphasis on innovation and entrepreneurship. Non-degree programs are designed to promote principles of innovation and entrepreneurship. Curriculum learning objectives include innovation knowledge. Continuing education in innovation is available for educators and staff members involved in teaching. Educators are encouraged to take up further and continuing education in innovation and entrepreneurship. The university is externally recognized as a center of innovation and entrepreneurship education. Educators maintain knowledge and connections with industry through tools such as academic and professional conferences. Educators routinely publish academic works (e.g. journal articles) in the field of innovation and entrepreneurship. Educators produce critical analyses of innovation and entrepreneurship questions. Educators are innovation partners in the university, generally speaking. Educators are proactive at seeking industry support and connection.

Actor Dimension	Proposed Items
Innovators (33)	There are performance measures and targets in place to address innovation activities. Rate of scientific paper publication meets or exceeds targets. Rate of patent applications meets or exceeds targets. Rate of patent grants meets or exceeds targets. Sales of patents generated from innovative activities meets or exceeds targets. Licensing of patents generated from innovation activities meets or exceeds targets. Overall revenue from commercialization of innovation activities meets or exceeds targets. Funding from private industry meets or exceeds targets. Public funding meets or exceeds targets. Private industry funding is available for innovation and research. Public industry funding is available for innovation and research. The university has reward systems that offer meaningful incentives for innovation and entrepreneurship. The incentive and reward system rewards innovation and entrepreneurship at all levels of the organization. The incentive and reward system rewards participation in innovation activities in all functional areas. Innovation and entrepreneurship role models are visible in the university. Students and early-career researchers have the opportunity to form relationships with researchers and innovators. Students and early-career researchers are proactively taught about development and commercialization of innovations. There are student enterprises for commercializing innovations. There are high-profile start-ups and spin-offs associated with the university. The university partners with one or more incubators to develop entrepreneurship activities. The university has partnerships with one or more venture capital firms to develop entrepreneurship activities. The number of start-ups and spin-offs created to develop and commercialize university innovation meets or exceeds targets. The university has a business innovation development program in place.

Actor Dimension	Proposed Items
	The business innovation development program is broadly considered as successful. The business innovation development program proactively seeks out innovations to assist in developing throughout the university. The number of faculty engaged in research meets or exceeds targets. Faculty have opportunities to commercialize innovation activities. Faculty have support for commercialization of innovation activities.

onnectors (16)	Researchers and educators maintain links with colleagues at other institutions, private industry and other organizations. Researchers and educators actively participate in research with colleagues at other institutions. Researchers and educators routinely engage in joint research with private industry and government bodies. The university has short-term innovation partnerships with public and private organizations, including governments, NGOs, private industry, and local communications. The university has long-term innovation partnerships with public and private organizations, including governments, NGOs, private industry, and local communications. The university has long-term innovation partnerships with its prior spin-offs and entrepreneurial activities. Internal collaborations result in substantial innovations. External collaborations result in substantial innovations. The university has adequate links with industry. The university actively cultivates increased links with industry. The university sets policy objectives that are specifically related to links with industry. There are set targets for collaboration for innovation. There are set targets for university innovation and entrepreneurship education, including enrollment and completion targets. University researchers and faculty members’ rate of collaboration with research partners in industry meets or exceeds targets. The number of courses addressing entrepreneurship meets or exceeds targets. The university has an established innovation and entrepreneurship educational track or program at the undergraduate level. The university has an established innovation and entrepreneurship educational track or program at the postgraduate level. The university hosts academic conferences and other events that support innovation and entrepreneurship research. The university promotes innovation and entrepreneurship in its publications (e.g. newsletters, websites). The university and its members play central roles in innovation and entrepreneurship journal publication. The university hosts preprint archives or other knowledge management resources for innovation and entrepreneurship. The university hosts informal social events to assist in network connections and social relationship formation for innovation and entrepreneurship. The university has a centralized office or hub for innovation and entrepreneurship coordination. The centralized office or innovation hub has a clearly defined policy for innovation and entrepreneurship coordination. The centralized office or innovation hub has active participation from leaders, innovators, and educators in the setting of innovation policy. The centralized office or innovation hub supports commercialization activities. The centralized office or innovation hub supports spin-offs. The centralized office or innovation hub supports funding efforts. The centralized office or innovation hub helps create connections between innovation actors. The innovation office or innovation hub is appropriately funded for the university’s innovation activities.

Actor Dimension	Proposed Items
Agents of Change (0)	Leaders and administrators have a responsibility to guide change. Educators are empowered to act as agents of change. Innovators are empowered to act as agents of change. University staff are empowered to act as agents of change. Students are empowered to act as agents of change. External stakeholders are empowered to act as agents of change. Change agents within the university can propose changes. There is a system in place to recommend changes. The university has a continuous improvement process within its innovation systems. Change is a topic addressed within undergraduate innovation curriculum. Change is a topic addressed within postgraduate innovation curriculum. The university welcomes change as a whole. There are mechanisms in place to facilitate change. The university's innovation processes can be changed if needed. There is a change management strategy in place in the university that addresses overall change. There is an organized process in place to proactively scan for changes as needed. There is a need to manage change effectively.

Are there any other assessment measures of an innovative university you would propose?

Round 2 (Development)

For each item:

1) Should this item be used to measure university innovation ecosystem performance? [Yes/No]

2) Does [Actor group] hold the primary responsibility for this item? [Yes/No]

3) Please assign the item to one of the proposed functional responsibility areas, or suggest another item.

Proposed Items
The university has a flexible organizational structure.
The university’s culture centralizes and prioritizes innovation and entrepreneurship.
The university leadership actively promotes and supports innovation and entrepreneurship.
University policy is oriented to innovation and entrepreneurship.
There are clear policies to facilitate innovation in the university.
University innovation policies emphasize the importance of STEM.
There are clear policies to facilitate entrepreneurship in the university.
There are clear policies to facilitate innovation and education entrepreneurship.
There are short-term objectives (under one year) in place to facilitate university innovation and entrepreneurship.
There are medium-term objectives (one to five years) in place to facilitate university innovation and entrepreneurship.
There are long-term objectives (five years or longer) in place to facilitate university innovation and entrepreneurship.
There is a monitoring mechanism in place to facilitate university innovation and entrepreneurship objectives.
There is a performance measurement mechanism in place to facilitate university innovation and entrepreneurship objectives.
University innovation strategy meets short-term objectives.
University innovation strategy meets medium-term objectives.
University innovation strategy meets long-term objectives.
University innovation strategy is routinely successful.
University staffing is oriented toward innovation and entrepreneurship.
When recruiting university educators and researchers, innovation performance is a key recruitment criterion.
Academic and research staff are selected in part for their expertise in innovation and/or entrepreneurship in their areas of specialism.
The university budget includes adequate funding to support innovation and entrepreneurship.
The university has financial and technological resources available to facilitate innovation by students, early career researchers, and others without external or independent funding.
The university’s resources are distributed fairly among innovation actors.
Members of the university (including administrators, staff, educators, researchers, and students) have access to sufficient resources for their education and innovation activities.
There is a mechanism in place to manage resource conflicts when required.
There is a review board or other mechanism to review assignment of resources and deal with resource conflicts.
Innovation at the university considers multiple stakeholders, including people and the environment.
There are clear mechanisms in place to ensure prioritization of key stakeholders.
There are specific policy objectives for stakeholder engagement.
University innovation activities draw on a wide range of stakeholder perspectives.

Stakeholders are consulted as appropriate depending on their interest in innovation.
Stakeholder engagement can be considered successful.
University vision is oriented to innovation and entrepreneurship.
University vision is clearly communicated in materials and policy.
University vision specifies purposes for innovation.
University vision considers innovation as a sustainable activity.
University vision for innovation is incorporated into policies and strategies.
University vision for innovation is translated to university innovation policies.
There are performance measures associated with the university vision.
There is a high-level managerial commitment to implementing innovation and entrepreneurship policies in the university.
University strategies are oriented toward creating conditions for innovation (e.g., organizational connections, funding and support).
The university works to influence national policy on university-based innovation and entrepreneurship.
The university's short-term strategy addresses innovation processes (e.g., basic research and applications, networking activities).
The university's strategy includes innovation and entrepreneurship as central objectives.
The university's short-term and medium-term strategies address innovation outcomes (e.g., patent issuance, licensing)
Internal and external stakeholders in innovation activities are identified at the university level.

Educators have positive attitudes toward innovation.
Educators take responsibility for students' innovation.
Educators act as innovators themselves.
Educators in non-STEM disciplines have an interest in innovation and entrepreneurship.

There are processes available for educators to gain access to resources for innovation and entrepreneurship activities.
Educators form connections outside the university for innovation and entrepreneurship activities.
The university has an established teaching program for innovation and entrepreneurship studies.
Principles of innovation and entrepreneurship are integrated into curriculum areas throughout the university.
Innovation and entrepreneurship learning opportunities are available to all students, regardless of academic discipline.
STEM degree courses place emphasis on innovation and entrepreneurship.
Non-STEM degrees place emphasis on innovation and entrepreneurship.
Curriculum learning objectives include innovation knowledge.
Continuing education in innovation is available for educators and staff members involved in teaching.
The university is externally recognized as a center of innovation and entrepreneurship education.
Educators maintain knowledge and connections with industry through tools such as academic and professional conferences.
Educators are proactive at seeking industry support and connection.
The university offers non-degree programs focused on innovation and entrepreneurship, like workshops, lectures and non-credit courses.
The university offers various training programs for innovation and entrepreneurship, such as laboratory roles, internships and work experience.
Number of educator links with industry meets or exceeds targets.
Student enrollment in innovation courses meets or exceeds targets.
Student satisfaction with innovation courses meets or exceeds targets.
Graduation from innovation degree courses meets or exceeds targets.

Student participation in innovation-oriented non-course learning, including laboratory research roles, work experience and internships, meets or exceeds targets.
Student participation in non-course innovation and entrepreneurship activities, such as workshops and lectures, meets or exceeds targets.
Student continuation in postgraduate innovation-oriented programs meets or exceeds targets.
Student intention to continue in innovation and entrepreneurship careers meets or exceeds targets.

Rate of scientific paper publication meets or exceeds targets.
Rate of patent applications meets or exceeds targets.
Rate of patent grants meets or exceeds targets.
Sales of patents generated from innovative activities meets or exceeds targets.
Licensing of patents generated from innovation activities meets or exceeds targets.
Overall revenue from commercialization of innovation activities meets or exceeds targets.
Funding from private industry meets or exceeds targets.
Public funding meets or exceeds targets.
Private industry funding is available for innovation and research.
Public industry funding is available for innovation and research.
The university has reward systems that offer meaningful incentives for innovation and entrepreneurship.
The incentive and reward system rewards innovation and entrepreneurship at all levels of the organization.
The incentive and reward system rewards participation in innovation activities in all functional areas.
Innovation and entrepreneurship role models are visible in the university.
Students and early-career researchers have the opportunity to form relationships with researchers and innovators.
The number of start-ups and spin-offs created to develop and commercialize university innovation meets or exceeds targets.
The university has a business innovation development program in place.
The business innovation development program is broadly considered as successful.
The number of faculty engaged in research meets or exceeds targets.
Faculty have opportunities to commercialize innovation activities.
Overall funding for innovation and entrepreneurship activities is adequate.
Internal funding is distributed to facilitate innovation at all levels of the university.
Training in innovation and entrepreneurship is available to students and researchers at all levels and disciplines.
Participation in staff and student training programs meets or exceeds targets.
Informal mentorship between researchers, academics and students are frequent.
Innovation role models have external presence (e.g., external research and industry connections.)
Faculty members are assessed on their participation in innovation and research as appropriate for specialty and position.

Researchers and educators maintain links with colleagues at other institutions, private industry and other organizations.
The university has short-term innovation partnerships with public and private organizations, including governments, NGOs, private industry, and local communications.
The university has long-term innovation partnerships with public and private organizations, including governments, NGOs, private industry, and local communications.
Internal collaborations result in substantial innovations.
The university has adequate links with industry.

University researchers and faculty members' rate of collaboration with research partners in industry meets or exceeds targets.
The number of courses addressing entrepreneurship meets or exceeds targets.
The university has an established innovation and entrepreneurship educational track or program at the undergraduate level.
The university has an established innovation and entrepreneurship educational track or program at the postgraduate level.
The university hosts academic conferences and other events that support innovation and entrepreneurship research.
The university has a centralized office or hub for innovation and entrepreneurship coordination.
The innovation office or innovation hub is appropriately funded for the university's innovation activities.
Researchers and educators across the university engage in cross-disciplinary cooperation.
Administrators, governors, researchers, educators and students have access to networks of innovation activity.
The university and its members participate in industry-wide innovation development activities as appropriate.
The innovation office or innovation hub serves as a coordination point for engagement with external partners, including government agencies, NGOs, private industry, and academics at other universities to facilitate innovation.

Round 3 (Confirmation)

For each item:

1) Should this item be used to measure university innovation ecosystem performance? [Yes/No]

2) Does [Actor group] hold the primary responsibility for this item? [Yes/No]

3) Does the item fall into the functional group assigned [Functional group]? [Yes/No]

1. The university has a flexible organizational structure.
2. The university's culture centralizes and prioritizes innovation and entrepreneurship.
3. The university leadership actively promotes and supports innovation and entrepreneurship.
4. University policy is oriented to innovation and entrepreneurship.
5. There is a high-level managerial commitment to implementing innovation and entrepreneurship policies in the university.
6. There are clear policies to facilitate innovation in the university.
7. There are clear policies to facilitate entrepreneurship in the university.
8. There are clear policies to facilitate innovation and education entrepreneurship.
9. The university's strategy includes innovation and entrepreneurship as central objectives.
10. University strategies are oriented toward creating conditions for innovation (e.g., organizational connections, funding and support).
11. The university works to influence national policy on university-based innovation and entrepreneurship.
12. The university's short-term strategy addresses innovation processes (e.g., basic research and applications, networking activities).
13. The university's short-term and medium-term strategies address innovation outcomes (e.g., patent issuance, licensing)
14. University innovation strategy is routinely successful.
15. University staffing is oriented toward innovation and entrepreneurship.
16. Academic and research staff are selected in part for their expertise in innovation and/or entrepreneurship in their areas of specialism.
17. The university budget includes adequate funding to support innovation and entrepreneurship.
18. The university has financial and technological resources available to facilitate innovation by students, early career researchers, and others without external or independent funding.
19. The university's resources are distributed fairly among innovation actors.
20. Internal and external stakeholders in innovation activities are identified at the university level.
21. Innovation at the university considers multiple stakeholders, including people and the environment.
22. University innovation activities draw on a wide range of stakeholder perspectives.
23. Stakeholders are consulted as appropriate depending on their interest in innovation.
24. Stakeholder engagement can be considered successful.
25. University vision is oriented to innovation and entrepreneurship.
26. University vision is clearly communicated in materials and policy.
27. University vision specifies purposes for innovation.
28. University vision considers innovation as a sustainable activity.
29. University vision for innovation is incorporated into policies and strategies.

30. Educators have positive attitudes toward innovation.
31. Educators take responsibility for students' innovation.
32. Educators act as innovators themselves.
33. The university has an established teaching program for innovation and entrepreneurship studies.
34. Principles of innovation and entrepreneurship are integrated into curriculum areas throughout the university.
35. The university offers non-degree programs focused on innovation and entrepreneurship, like workshops, lectures and non-credit courses.
36. The university offers various training programs for innovation and entrepreneurship, such as laboratory roles, internships and work experience.
37. Innovation and entrepreneurship learning opportunities are available to all students, regardless of academic discipline.
38. STEM degree courses place emphasis on innovation and entrepreneurship.
39. Curriculum learning objectives include innovation knowledge.
40. Continuing education in innovation is available for educators and staff members involved in teaching.
41. The university is externally recognized as a center of innovation and entrepreneurship education.
42. Number of educator links with industry meets or exceeds targets.
43. Educators maintain knowledge and connections with industry through tools such as academic and professional conferences.
44. Educators are proactive at seeking industry support and connection.
45. Student enrollment in innovation courses meets or exceeds targets.
46. Student satisfaction with innovation courses meets or exceeds targets.
47. Graduation from innovation degree courses meets or exceeds targets.
48. Student participation in innovation-oriented non-course learning, including laboratory research roles, work experience and internships, meets or exceeds targets.
49. Student participation in non-course innovation and entrepreneurship activities, such as workshops and lectures, meets or exceeds targets.
50. Student continuation in postgraduate innovation-oriented programs meets or exceeds targets.
51. Student intention to continue in innovation and entrepreneurship careers meets or exceeds targets.

52. Rate of scientific paper publication meets or exceeds targets.
53. Rate of patent applications meets or exceeds targets.
54. Rate of patent grants meets or exceeds targets.
55. Sales of patents generated from innovative activities meets or exceeds targets.
56. Licensing of patents generated from innovation activities meets or exceeds targets.
57. Overall revenue from commercialization of innovation activities meets or exceeds targets.
58. Funding from private industry meets or exceeds targets.
59. Public funding meets or exceeds targets.
60. Private industry funding is available for innovation and research.
61. Public industry funding is available for innovation and research.
62. Overall funding for innovation and entrepreneurship activities is adequate.
63. Internal funding is distributed to facilitate innovation at all levels of the university.
64. The university has reward systems that offer meaningful incentives for innovation and entrepreneurship.
65. The incentive and reward system rewards innovation and entrepreneurship at all levels of the organization.
66. The incentive and reward system rewards participation in innovation activities in all functional areas.
67. Training in innovation and entrepreneurship is available to students and researchers at all levels and disciplines.
68. Participation in staff and student training programs meets or exceeds targets.
69. Informal mentorship between researchers, academics and students are frequent.
70. Innovation and entrepreneurship role models are visible in the university.
71. Innovation role models have external presence (e.g., external research and industry connections).
72. Students and early career researchers have the opportunity to form relationships with researchers and innovators.
73. The number of start-ups and spin-offs created to develop and commercialize university innovation meets or exceeds targets.
74. The university has a business innovation development program in place.
75. The business innovation development program is broadly considered as successful.
76. The number of faculty engaged in research meets or exceeds targets.
77. Faculty have opportunities to commercialize innovation activities.
78. Faculty members are assessed on their participation in innovation and research as appropriate for specialty and position.

79. Researchers and educators maintain links with colleagues at other institutions, private industry and other organizations.
80. The university has short-term innovation partnerships with public and private organizations, including governments, NGOs, private industry, and local communications.
81. The university has long-term innovation partnerships with public and private organizations, including governments, NGOs, private industry, and local communications.
82. Researchers and educators across the university engage in cross-disciplinary cooperation.
83. Administrators, governors, researchers, educators and students have access to networks of innovation activity.
84. Internal collaborations result in substantial innovations.
85. The university has adequate links with industry.
86. University researchers and faculty members' rate of collaboration with research partners in industry meets or exceeds targets.
87. The university and its members participate in industry-wide innovation development activities as appropriate.
88. The number of courses addressing entrepreneurship meets or exceeds targets.
89. The university has an established innovation and entrepreneurship educational track or program at the undergraduate level.
90. The university has an established innovation and entrepreneurship educational track or program at the postgraduate level.
91. The university has a centralized office or hub for innovation and entrepreneurship coordination.
92. The innovation office or innovation hub is appropriately funded for the university's innovation activities.
93. The innovation office or innovation hub serves as a coordination point for engagement with external partners, including government agencies, NGOs, private industry, and academics at other universities to facilitate innovation.

Appendix B: Survey

Thank you for agreeing to participate in my survey. This study is intended to investigate and develop a consensus regarding the performance measurement of university innovation ecosystems in Asian universities. The ultimate goal is to develop a performance measurement tool that universities can use to guide and assess their innovation ecosystem development in accordance with national and institutional objectives and their current position.

Within the study, you are asked to apply your knowledge and insights about university innovation regarding a theoretical university that is at the cutting edge of innovation ecosystem development. You will be shown a series of performance assessment items. You are then asked to rate the importance of this performance assessment item to the university's innovation performance.

This study is confidential, but some personal information is collected. This information is kept confidential and is only used in aggregate for a respondent profile.

Please send any questions or comments to:

[Researcher information]

Part 1 The University Innovation Ecosystem

These items are about the ideal university innovation ecosystem. This can be roughly defined as the university's web of interrelationships among actors and organizations seeking to promote innovation and new technology development, drawing upon various human and material resources to achieve these goals. In the next few sections, you will be shown a series of statements about a theoretical innovative university. Please rate each of the items individually based on how important you think it is for an innovative university, using the following scale:

1: Not at all important

2: Not very important

3: A little important

4: Somewhat important

5: Very important

1. The university has a flexible organizational structure.
2. The university's culture centralizes and prioritizes innovation and entrepreneurship.
3. The university leadership actively promotes and supports innovation and entrepreneurship.
4. University policy is oriented to innovation and entrepreneurship.
5. There is a high-level managerial commitment to implementing innovation and entrepreneurship policies in the university.
6. There are clear policies to facilitate innovation in the university.
7. There are clear policies to facilitate entrepreneurship in the university.
8. There are clear policies to facilitate innovation and education entrepreneurship.
9. The university's strategy includes innovation and entrepreneurship as central objectives.
10. University strategies are oriented toward creating conditions for innovation (e.g., organizational connections, funding and support).
11. The university works to influence national policy on university-based innovation and entrepreneurship.
12. The university's short-term strategy addresses innovation processes (e.g., basic research and applications, networking activities).
13. The university's short-term and medium-term strategies address innovation outcomes (e.g., patent issuance, licensing)
14. University innovation strategy is routinely successful.
15. University staffing is oriented toward innovation and entrepreneurship.
16. Academic and research staff are selected in part for their expertise in innovation and/or entrepreneurship in their areas of specialism.
17. The university budget includes adequate funding to support innovation and entrepreneurship.
18. The university has financial and technological resources available to facilitate innovation by students, early career researchers, and others without external or independent funding.
19. The university's resources are distributed fairly among innovation actors.
20. Internal and external stakeholders in innovation activities are identified at the university level.
21. Innovation at the university considers multiple stakeholders, including people and the environment.
22. University innovation activities draw on a wide range of stakeholder perspectives.
23. Stakeholders are consulted as appropriate depending on their interest in innovation.
24. Stakeholder engagement can be considered successful.
25. University vision is oriented to innovation and entrepreneurship.
26. University vision is clearly communicated in materials and policy.
27. University vision specifies purposes for innovation.
28. University vision considers innovation as a sustainable activity.
29. University vision for innovation is incorporated into policies and strategies.

30. Educators have positive attitudes toward innovation.
31. The university has an established teaching program for innovation and entrepreneurship studies.
32. Principles of innovation and entrepreneurship are integrated into curriculum areas throughout the university.
33. The university offers non-degree programs focused on innovation and entrepreneurship, like workshops, lectures and non-credit courses.
34. The university offers various training programs for innovation and entrepreneurship, such as laboratory roles, internships and work experience.
35. Innovation and entrepreneurship learning opportunities are available to all students, regardless of academic discipline.
36. STEM degree courses place emphasis on innovation and entrepreneurship.
37. Curriculum learning objectives include innovation knowledge.
38. Continuing education in innovation is available for educators and staff members involved in teaching.
39. The university is externally recognized as a center of innovation and entrepreneurship education.
40. Number of educator links with industry meets or exceeds targets.
41. Educators maintain knowledge and connections with industry through tools such as academic and professional conferences.
42. Educators are proactive at seeking industry support and connection.
43. Student enrolment in innovation courses meets or exceeds targets.
44. Student satisfaction with innovation courses meets or exceeds targets.
45. Graduation from innovation degree courses meets or exceeds targets.
46. Student participation in innovation-oriented non-course learning, including laboratory research roles, work experience and internships, meets or exceeds targets.
47. Student participation in non-course innovation and entrepreneurship activities, such as workshops and lectures, meets or exceeds targets.
48. Student continuation in postgraduate innovation-oriented programs meets or exceeds targets.
49. Student intention to continue in innovation and entrepreneurship careers meets or exceeds targets.

50. Rate of scientific paper publication meets or exceeds targets.
51. Rate of patent applications meets or exceeds targets.
52. Rate of patent grants meets or exceeds targets.
53. Sales of patents generated from innovative activities meets or exceeds targets.
54. Licensing of patents generated from innovation activities meets or exceeds targets.
55. Overall revenue from commercialization of innovation activities meets or exceeds targets.
56. Funding from private industry meets or exceeds targets.
57. Public funding meets or exceeds targets.
58. Private industry funding is available for innovation and research.
59. Public industry funding is available for innovation and research.
60. Overall funding for innovation and entrepreneurship activities is adequate.
61. Internal funding is distributed to facilitate innovation at all levels of the university.
62. The university has reward systems that offer meaningful incentives for innovation and entrepreneurship.
63. The incentive and reward system rewards innovation and entrepreneurship at all levels of the organization.
64. The incentive and reward system rewards participation in innovation activities in all functional areas.
65. Training in innovation and entrepreneurship is available to students and researchers at all levels and disciplines.
66. Participation in staff and student training programs meets or exceeds targets.
67. Informal mentorship between researchers, academics and students are frequent.
68. Innovation and entrepreneurship role models are visible in the university.
69. Innovation role models have external presence (e.g., external research and industry connections).
70. Students and early career researchers have the opportunity to form relationships with researchers and innovators.
71. The number of start-ups and spin-offs created to develop and commercialize university innovation meets or exceeds targets.
72. The university has a business innovation development program in place.
73. The business innovation development program is broadly considered as successful.
74. The number of faculty engaged in research meets or exceeds targets.
75. Faculty have opportunities to commercialize innovation activities.
76. Faculty members are assessed on their participation in innovation and research as appropriate for specialty and position.

77. Researchers and educators maintain links with colleagues at other institutions, private industry and other organizations.
78. The university has short-term innovation partnerships with public and private organizations, including governments, NGOs, private industry, and local communications.
79. The university has long-term innovation partnerships with public and private organizations, including governments, NGOs, private industry, and local communications.
80. Researchers and educators across the university engage in cross-disciplinary cooperation.
81. Administrators, governors, researchers, educators and students have access to networks of innovation activity.
82. Internal collaborations result in substantial innovations.
83. The university has adequate links with industry.
84. University researchers and faculty members' rate of collaboration with research partners in industry meets or exceeds targets.
85. The university and its members participate in industry-wide innovation development activities as appropriate.
86. The number of courses addressing entrepreneurship meets or exceeds targets.
87. The university has an established innovation and entrepreneurship educational track or program at the undergraduate level.
88. The university has an established innovation and entrepreneurship educational track or program at the postgraduate level.
89. The university has a centralized office or hub for innovation and entrepreneurship coordination.
90. The innovation office or innovation hub is appropriately funded for the university's innovation activities.
91. The innovation office or innovation hub serves as a coordination point for engagement with external partners, including government agencies, NGOs, private industry, and academics at other universities to facilitate innovation.

Part 2: Respondent Information

Please provide the following information. This information will not be associated with your responses and is only used for tracking and aggregate respondent profile information.

Type of organization you work for: [University / Other higher education institution / Government agency / Non-governmental organization / Private sector / Other]

Organization role: [Open response]

Years of experience in role: [Open response]

Appendix C. Assessment Rubric

Directions

The following statements represent activities and processes that can be observed within the university innovation ecosystem. Please reflect on each individual statement and rate it on the following scale of 0 to 6:

0: This activity has not been implemented in the university at all, and there have not been any significant efforts to implement this activity.

1: This activity does sometimes occur within the university. However, it is an ad hoc activity, driven by bottom-up interest (or even a single individual in the community). There is no active management of the performance.

2: This activity occurs within the university. However, it is managed reactively when it is performed, and is localized. For example, it may be occurring within a single academic department or research group, but not have gained much interest at the university level.

3: This activity is clearly defined within a university-wide policy or process. There is information available to allow it to be used across the university. It is managed proactively and is part of the university's day-to-day activity.

4: This activity is clearly defined within university policies and processes, as in 3. Additionally, there are quantitative targets set for the university, groups or departments, and/or individuals, and performance is controlled in order to meet these objectives.

5: This activity is defined within the university-wide policy or process, as in 3. It is quantitatively managed with targets and performance monitoring, as in 4. Now, the emphasis is on refining the activity to optimize outcomes.

If you do not have sufficient information or feel uncomfortable with answering a specific item, select "NA". In this case, your response will not be included in the overall results for this item.

Dimension	Sub-Dimension	Item
Leaders	Governance and Culture (GC)	GC1. The university has a flexible organizational structure. GC2. The university's culture centralizes and prioritizes innovation and entrepreneurship. GC3. The university leadership actively promotes and supports innovation and entrepreneurship.
	Policy and Strategies (PS)	PS1. University policy is oriented to innovation and entrepreneurship. PS2. There is a high-level managerial commitment to implementing innovation and entrepreneurship policies in the university. PS3. There are clear policies to facilitate innovation in the university. PS4. There are clear policies to facilitate entrepreneurship in the university. PS5. There are clear policies to facilitate innovation and entrepreneurship education. PS6. The university's strategy includes innovation and entrepreneurship as central objectives. PS7. University strategies are oriented toward creating conditions for innovation (e.g., organizational connections, funding and support). PS8. The university works to influence national policy on university-based innovation and entrepreneurship. PS9. The university's short-term strategy addresses innovation processes (e.g., basic research and applications, networking activities). PS10. The university's short-term and medium-term strategies address innovation outcomes (e.g., patent insurance, licensing). PS11. University innovation strategy is routinely successful.

Dimension	Sub-Dimension	Item
	Resource Management (LRM)	LRM1.University staffing is oriented toward innovation and entrepreneurship. LRM2. Academic and research staff are selected in part for their expertise in innovation and entrepreneurship. LRM3. The university budget includes adequate funding to support innovation and entrepreneurship. LRM4. The university has financial and technological resources available to facilitate innovation by students, early career researchers, and others without external or independent funding. LRM5. The university's resources are distributed fairly among innovation actors.
	Stakeholder Engagement (SE)	SE1. Internal and external stakeholders in innovation activities are identified at the university level. SE2. Innovation at the university level considers multiple stakeholders, including people and the environment. SE3. University innovation activities draw on a wide range of stakeholder perspectives. SE4. Stakeholders are consulted as appropriate depending on their interest in innovation. SE5. Stakeholder engagement can be considered successful.
	Vision (V)	VI1. University vision is oriented to innovation and entrepreneurship. V2. University vision is clearly communicated in materials and policy. V3. University vision specifies purposes for innovation. V4. University vision considered innovation as a sustainable activity. V5. University vision for innovation is incorporated into policies and strategies.

Dimension	Sub-Dimension	Item
Educators	Curriculum and Teaching (CT)	CT1. Educators have positive attitudes towards innovation. CT2. The university has an established teaching program for innovation and entrepreneurship studies. CT3. Principles of innovation and entrepreneurship are integrated into curriculum areas throughout the university. CT4. The university offers non-degree programs focused on innovation and entrepreneurship, like workshops, lectures, and non-credit courses. CT5. The university offers various training programs for innovation and entrepreneurship, such as laboratory roles, internships, and work experience. CT6. Innovation and entrepreneurship learning opportunities are available to all students, regardless of academic discipline. CT7. STEM degree courses place emphasis on innovation and entrepreneurship. CT8. Curriculum learning objectives include innovation knowledge. CT9. Continuing education in innovation is available for educators and staff members involved in teaching. CT10. The university is externally recognized as a center of innovation and entrepreneurship education.
	Industry Involvement (II)	II1. Number of educator links with industry meets or exceeds targets. II2. Educators maintain knowledge and connections with industry through tools such as academic and professional conferences. II3. Educators are proactive at seeking industry support and connection.

Dimension	Sub-Dimension	Item
	Learning Outcomes (LO)	LO1. Student enrollment in innovation courses meets or exceeds targets. LO2. Student satisfaction with innovation courses meets or exceeds targets. LO3. Graduation from innovation degree courses meets or exceeds targets. LO4. Student participation and innovation oriented non-course learning including laboratory research roles, work experience and internships, meets or exceeds targets. LO5. Student participation in non-course innovation and entrepreneurship activities, such as workshops and lectures, meets or exceeds targets. LO6. Student continuation in post graduate innovation oriented programs meets or exceeds targets. LO7. Student intention to continue in innovation and entrepreneurship careers meets or exceeds targets.
Innovators	Production (IP)	IP1. Rate of scientific paper publication meets or exceeds targets. IP2. Rate of patent applications meets or exceeds target. IP3. Rate of patent grants meets or exceeds targets.
	Commercialization (IC)	IC1. Sales of patents generated from innovative activities meets or exceeds targets. IC2. Licensing of patents generated from innovation activities meets or exceeds targets. IC3. Overall revenue from commercialization of innovation activities meets or exceeds targets.

Dimension	Sub-Dimension	Item
	Funding and Financial Management (FFM)	FFM1. Funding from private industry meets or exceeds targets. FFM2. Public funding meets or exceeds targets. FFM3. Private industry funding is available for innovation and research. FFM4. Public industry funding is available for innovation and research. FFM5. Overall funding for innovation and entrepreneurship activities is adequate. FFM6. Internal funding is distributed to facilitate innovation at all levels of the university.
	Incentive and Reward Systems (IRS)	IRS1. The university has reward systems that offer meaningful incentives for innovation and entrepreneurship. IRS2. The incentive and reward system rewards innovation and entrepreneurship at all levels of the organization. IRS3. The incentive and reward system rewards participation in innovation activities in all functional areas.
	Training and Mentorship (TM)	TM1. Trading in innovation and entrepreneurship is available to students and teachers at all levels and disciplines. TM2. Participation in staff and student training programs meets or exceeds targets. TM3. Informal mentorship between researchers, academics, and students are frequent.
	Role Models (RM)	RM1. Innovation and entrepreneurship role models are visible in the university. RM2. Innovation role models have external presence (e.g., external research and industry connections). RM3. Students and early career researchers have the opportunity to form relationships with researchers and innovators.

Dimension	Sub-Dimension	Item
	Business and Innovation Development (BID)	BID1. The number of start-ups and spinoffs created to develop and commercialize university innovation meets or exceeds targets. BID2. The university has a Business Innovation development program in place. BID3. The Business Innovation development program is broadly considered as successful.
	Faculty Involvement FI)	FI1. The number of faculty engaged in research meets or exceeds targets. FI2. Faculty have opportunities to commercialize innovation activities. FI3. Faculty members are assessed on their participation in innovation and research as appropriate for specialty and position.
Connectors	External collaboration (EC)	EC1. Researchers and educators maintain links with colleagues at other institutions, private industry, and other organizations. EC2. The university has short term innovation partnerships with public and private organizations including governments, NGOs, private industries, and local communities. EC3. The university has long term innovation partnerships with public and private organizations, including governments, NGOs, private industry, and local communities.
	Internal collaboration (IC)	IC1. Researchers and educators across the university engage in cross-disciplinary cooperation. IC2. Administrators, governors, researchers, educators, and students have active networks of innovation activity. IC3. Internal collaborations result in substantial innovations.

Dimension	Sub-Dimension	Item
	Industry Connections (ICO)	ICO1. The university has adequate links with industry. ICO2. University researchers and faculty members’ rate of collaboration with research partners in university meets or exceeds targets. ICO3. The university and its members participate in industry wide innovation development activities as appropriate.
	Entrepreneurial Education (EE)	EE1. The number of courses addressing entrepreneurship meets or exceeds targets. EE2. The university has an established innovation and entrepreneurship educational track or program at the undergraduate level. EE3. The university has an established innovation and entrepreneurship educational track or program at the graduate level.
	Entrepreneurial Hub (EH)	EH1. The university has a centralized office or hub for innovation and entrepreneurship coordination. EH2. The innovation office or innovation hub is appropriately funded for the university’s innovation activities. EH3. The innovation office or an innovation hub serves as a coordination point for engagement with external partners, including government agencies, NGOs, private industry, and academics and other universities to facilitate innovation.

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